FINAL ECOSYSTEM RESTORATION REPORT AND ENVIRONMENTAL ASSESSMENT

Gerritsen Creek Ecosystem Restoration Section 1135

Brooklyn, NY

Prepared by:

U.S Army Corps of Engineers
New York District
26 Federal Plaza
New York, NY 10278-0090

October 2003

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EXECUTIVE SUMMARY

The New York District of the U.S. Army Corps of Engineers (USACE) has completed this Integrated Ecosystem Restoration Report/Environmental Assessment (ERR/EA), in accordance with the requirements of the National Environmental Policy Act (NEPA), *Procedures for Implementing NEPA* Engineer Regulation (ER)-200-2-2 (USACE, 1988), and the USACE, *Ecosystem Restoration – Supporting Policy Information* ER 1165-2-502 (USACE, 1999), and the *Planning Guidance Notebook* ER 1105-2-100 (USACE, 2000). The purpose of the ERR/EA is to assess the need for restoring the existing degraded habitat, evaluate the environmental effects of the restoration activities, and determine a design plan that maximizes the environmental benefits while minimizing the economic costs for the Gerritsen Creek Ecosystem Restoration Project.

The purpose of the project is to ameliorate the adverse impacts associated with the past filling activities on the project site, with the overall purpose being to improve the environmental quality of the area. This area was altered in the past due to dredging and filling activities and, as a result, is less productive than the pre-existing ecosystem habitat.

The Gerritsen Creek ecosystem restoration is being conducted under Section 1135 of the Water Resources Development Act of 1986, as amended. Under Section 1135, the USACE is authorized to review the need for modifications of existing projects for the purpose of providing measures to improve environmental quality and is authorized to address degradation of the environment caused by a past USACE project.

The Gerritsen Creek project site targeted for ecosystem restoration is an approximately 67-acre site that lies within the Jamaica Bay watershed in Marine Park, Brooklyn, New York. Field observations of the site in its existing state indicate that the ecology of the area is severely degraded, primarily due to past activities that included dredging and filling activities. These activities have resulted in the loss of tidal wetlands and open water areas, and the predominance of common reed (*Phragmites australis*).

Based on the preliminary investigations, it is evident that a small fringe of healthy tidal wetlands exists on site, and larger areas of healthy tidal wetlands exist nearby within Marine Park and Jamaica Bay. Therefore, it is likely that the disturbed areas within the project site that received fill in the past can be restored to healthy tidal wetland ecosystems. The preliminary investigations also indicate that the upland areas that have been used in the past to dispose of household waste can be restored to coastal grassland, an estuarine habitat in short supply in the Jamaica Bay watershed.

The proposed project will restore approximately 35.5 acres of habitat, including approximately 20.5 acres of inter-tidal salt marsh and approximately 15 acres of coastal/maritime grassland. The proposed restoration will be accomplished through a combination of excavation, placement, recontouring, and native species' plantings.

The proposed project is the result of an analysis of three initial alternatives for restoring the disturbed areas on site to healthy tidal marshes and coastal grassland. A fourth alternative was added after it was discovered during site investigations that a major portion of the area to be restored through the three initial alternatives contained trash that would have to be removed, adversely impacting the cost of implementing these alternatives. The fourth alternative extended

the project along the Mill Creek shoreline and incorporated new design features including additional tidal channels and open water areas and an increase in the coastal grassland areas. According to the Cost Effectiveness analysis, the fourth alternative provided the greatest economic benefits at the lowest cost.

As the analysis of the site restoration options was progressed and further refined, five sub-alternatives were developed for Alternative 4 to determine the best option for restoring the Gerritsen Creek site. These sub-alternatives were developed by delineating the approximate boundaries of the five watershed reaches located within Alternative 4. The fourth sub-alternative, Alternative 4D, was determined to be the "best buy;" therefore, it was chosen as the recommended plan and advanced to the Design Drawings.

The design objective of the recommended plan is to increase the twice-daily tidal inundation across as much of the project site to the extent practicable by converting the *Phragmites*-dominated areas that lie adjacent to the existing salt marsh fringes to a healthy tidal ecosystem. The focus of the excavation is limited to these specific *Phragmites*-dominated areas, while avoiding the large landfilled area located in the northern portion of the site.

The design will include the preservation of sandy beaches located at the southeastern end of the site, for utilization by horseshoe crabs. The design also includes the creation of microniches through the site to further increase habitat diversity. Two salt pannes will be located within the low marsh areas, positioned at slightly lower elevations to allow for tidal flows to enter the pannes, but not drain as quickly as other areas in the marsh. Small open water areas will be located at the ends of two of the created tidal channels so that approximately 0.5 feet of water remains in the pools throughout the tidal cycle. The tidal channels will function primarily to bring tidal flows to all areas of the salt marsh, allowing for proper tidal inundation periods, but will also provide for additional habitat. Additional design features include an extension of the pedestrian trail, addition of a small boardwalk where the existing trail would traverse the proposed low marsh and one of the tidal channels, and addition of another overlook, providing view of the restored marsh.

The project's non-federal sponsor, The City of New York Department of Parks and Recreation (NYCDPR), is fully supportive of measures to restore the degraded ecosystem. In addition, the New York State Department of Environmental Conservation favors the restoration efforts, and the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service, and the U.S. Environmental Protection Agency (USEPA) support the restoration project. Appendix A contains the USFWS's Final Fish and Wildlife Coordination Act Report, which states its support of the project as long as the following conditions are met: 1) reduce the opportunities for common reed to become established; 2) increase the sinuosity of the tidal creeks to improve creek bank stability and increase fish habitat; and 3) monitor shoreline areas to ensure that no significant erosion is occurring.

Furthermore, the project complements the goals and efforts of other state and regional plans, notably the New York/New Jersey Harbor Estuary Program, a National Estuary Program led by the USEPA, whose Comprehensive Conservations and Management Plan targets Jamaica Bay as one of two areas deserving special protection. The North American Waterfowl Management Plan, an international agreement signed in 1986 that seeks to increase waterfowl populations through increasing and restoring wetland habitat, would also be supported by the recommended action.

Although the acreage involved in the proposed restoration at Gerritsen Creek is only a fraction of the acreage that historically existed in the area, the effect of its restoration on the ecological resources of the stressed and degraded Jamaica Bay system will be compounded and complemented by the eventual implementation of other restoration sites in Jamaica Bay currently under study by the USACE, as identified in the Jamaica Bay Navigational Channels and Shoreline Environmental Surveys Report (USACE, 1997). In combination with potential management actions resulting from New York City Department of Environmental Protection's Use and Standards Attainment Project and combined sewer overflow abatement to improve the overall water quality of Jamaica Bay, the Gerritsen Creek project has the potential to play an important role in significantly improving the environmental quality of the area and adding to the habitat acreage that has been lost over the years.

The environmental effects of the recommended plan on the physical, ecological, cultural, aesthetic, socioeconomic, and recreational conditions of the existing site were evaluated. Implementation of the recommended plan will result in improved tidal flushing and water quality at the site and surrounding areas. The permanent conversion of relatively degraded wetland and upland vegetation to valuable salt marsh wetland and coastal/maritime grassland habitats will benefit many fish and wildlife species. The restored ecosystem will reduce non-native species dominance and increase biodiversity, enhancing the amount and quality of habitat and food sources for wildlife. In addition, implementation of the plan will have long-term positive effects on the recreational and aesthetic conditions of the site, including enhanced unobstructed viewsheds, additional pedestrian trails, increased access to the shoreline in some areas, and additional boardwalks for an increase in the number of vantage points. The project will further serve to increase the educational value of the environmental center that NYCDPR recently opened at the head of Gerritsen Creek.

The results of the evaluation of environmental effects of the recommended plan on the project site established that implementation of the plan will have no negative impacts on the quality of the environment. While temporary impacts may occur during construction, work will be accomplished during low tidal periods and best management practices will be utilized for erosion and sedimentation control. Therefore, given that there are no anticipated long-term, adverse impacts associated with the implementation of the recommended plan, a Finding of No Significant Impact (FONSI) has been determined for this action.

INTEGRATED ECOSYSTEM RESTORATION REPORT/ENVIRONMENTAL ASSESSMENT MARINE PARK, BROOKLYN, NEW YORK

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1.1 Purpose and Need

The purpose of the project is to ameliorate the adverse impacts associated with the past filling activities on the project site, with the overall purpose being to improve the environmental quality of the area. This area was altered in the past due to dredging and filling activities and, as a result, is less productive than the pre-existing ecosystem habitat. The remnant salt marshes can no longer provide the quality of habitat for avian and fish species provided in their original state. The overall goal of restoration will be to restore the pre-existing functions by recontouring uplands to intertidal elevations, removing invasive species, replanting with native species, and restoring tidal marsh and coastal grassland habitats.

An Integrated Ecosystem Restoration Report/Environmental Assessment (ERR/EA) has been completed by the New York District of the U.S. Army Corps of Engineers (USACE), according to the requirements of the National Environmental Policy Act (NEPA), to assess the need for modifying the existing degraded habitat, evaluate the effects of the restoration activities, and determine a solution that maximizes the environmental benefits while minimizing the economic costs.

1.2 Project Area Description

The project area is located within the Jamaica Bay Federal navigation channel, which extends from offshore of Rockaway Point, Queens, through Rockaway Inlet and bisects at the southern edge of Floyd Bennett Field, Brooklyn, with one branch extending north into the upper part of Jamaica Bay and a second branch extending east into lower Jamaica Bay, in New York City, New York. The Gerritsen Creek project site targeted for ecosystem restoration is an approximately 67-acre site that lies within the Jamaica Bay watershed in Marine Park. Marine Park is a 798-acre park that consists primarily of the salt marshes and uplands that flank Gerritsen Creek, as well as the lands located underwater.

Historically, the project area was primarily a salt marsh, part of the extensive coastal wetland community of Jamaica Bay, renowned for the abundance and diversity of its shellfish. However, within the past century, the salt marsh community at Gerritsen Creek was altered by the dredging and filling activities associated with the construction and maintenance of the Jamaica Bay Federal navigation channel. These impacts were further compounded by landfilling activities associated with the disposal of nonhazardous waste materials in the early part of the 20th century. These activities contributed to habitat alteration and fragmentation, resulting in the degradation of habitat for numerous species of coastal birds, fish, and invertebrates, creating a significant disruption to the area's entire interconnected coastal ecology. However, even after experiencing significant losses in acreage that have reduced its ecological productivity, Gerritsen Creek and the Jamaica Bay environs are regionally and nationally important as a coastal resource, in large part because the area still contains a relatively large tract of contiguous habitat.

Field observations indicate that the ecology of the area is severely degraded, primarily due to past activities that included dredging and filling activities. These activities have resulted in the loss of tidal wetlands and open water areas, and the predominance of common reed (*Phragmites australis*). In addition, coastal processes and watercraft activities are causing erosion of salt marsh cordgrass (*Spartina alterniflora*) areas along some shoreline areas.

1.3 Proposed Action and Anticipated Effects

The preferred restoration alternative includes the restoration of the shoreline along Mill Creek, in addition to the shoreline areas along Gerritsen Creek. The restoration design focuses on restoring tidal flow to several areas on site, creating a native grassland meadow in adjacent upland areas, and promoting overall ecological diversity, while preserving the passive recreation uses that currently exist on site. Other design features include adding more tidal channels to increase the interspersion of channel and marsh fringe; marrying salt panne areas with two of the tidal channels and adding open water areas to others to increase vegetative and habitat diversity; creating a *Phragmites* disposal area that is completely surrounded by a trail to inhibit invasion into marsh areas; and increasing the acreage of restored maritime grassland to reduce excavation requirements in landfill areas.

The proposed project will provide many environmental benefits including increased tidal flushing; enrichment of degraded ecosystems; increased biodiversity; reduction of non-native species invasion and preclusion of further colonization; improvement of water quality; and enhancement of fish and wildlife habitat. Although the acreage involved in the proposed restoration at Gerritsen Creek is only a fraction of the acreage that historically existed in the area, the effect of its restoration on the ecological resources of the stressed and degraded Jamaica Bay system will be compounded and complemented by the eventual implementation of other restoration sites in Jamaica Bay.

No long-term, adverse impacts are anticipated as a result of implementing the recommended plan. In fact, as stated above, the recommended plan will have a positive impact on the environment at the site and surrounding areas. In regards to air quality, heavy equipment used during construction may contribute minor amounts of carbon monoxide or other pollutants in the immediate vicinity of the project site. However, construction activities would have no significant or long-term impacts on air quality. A General Conformity Record of Non-applicability will be submitted to the Chief of Planning, New York District of the USACE for signature, pending completion of the Plans and Specifications Phase of this project. Based on the information deduced on the current 30 percent design, it appears that emission calculations put the project under the conformity threshold value of 25 tons per year for nitrous oxide.

1.4 Conclusion

Given that there are no anticipated long-term, adverse impacts associated with the implementation of the recommended plan, a Finding of No Significant Impact (FONSI) has been determined for this action. Furthermore, as the recommended plan will have no negative impacts on the quality of the environment, an Environmental Impact Statement is not required.

Date:_____

_____
John B. O'Dowd
Colonel, Corps of Engineers
District Engineer

PART 2 – INTRODUCTION

The New York District of the USACE has prepared an Integrated ERR/EA to address the proposed habitat restoration plans for the project site located along Gerritsen and Mill Creeks in the Borough of Brooklyn, New York, Congressional District 9. The scope of this Integrated ERR/EA is to document the restoration planning and analysis process, which includes an evaluation of four alternative plans, the selection of one plan that maximizes ecosystem restoration benefits and minimizes costs, and a presentation to the public of information on the potential benefits and impacts associated with the proposed restoration project. This project scope is consistent with the USACE objective of National Ecosystem Restoration.

Following a request from The City of New York Department of Parks and Recreation (NYCDPR), the preliminary study and review that led up to this Integrated ERR/EA began in September 2000. The New York District completed a Preliminary Restoration Plan in January 2001. The Ecosystem Restoration Phase began in September 2001 and included a Preliminary Alternatives Restoration Report that was completed in August 2002. The selected alternative plan was presented to the public in a series of public meetings in November and December 2002.

This Integrated ERR/EA includes the documentation necessary to meet the requirements of NEPA, *Procedures for Implementing NEPA* Engineer Regulation (ER)-200-2-2 (USACE, 1988), *Ecosystem Restoration – Supporting Policy Information* ER 1165-2-502 (USACE, 1999), and the *Planning Guidance Notebook* ER 1105-2-100 (USACE, 2000).

2.1 Site Description and Location

The Gerritsen Creek project site targeted for ecosystem restoration is an approximately 67-acre site that lies within the Jamaica Bay watershed in Marine Park (Figure 2). Marine Park is a 798-acre park that consists primarily of the salt marshes and uplands that flank Gerritsen and Mill Creeks, as well as the lands located underwater.

The project area is located along Mill Creek, which is a tributary to Jamaica Bay. Jamaica Bay contains a federal navigation channel extending from offshore of Rockaway Point, Queens, through Rockaway Inlet and bisects at the southern edge of Floyd Bennett Field, Brooklyn, with one branch extending north into the upper part of Jamaica Bay and a second branch extending east into lower Jamaica Bay, in New York City, New York (Figure 1).

2.2 Background Information

Historically, the project area was primarily a salt marsh (Figure 3). In the early 1900's, the salt marsh community of Gerritsen Creek was part of the extensive coastal wetland community of Jamaica Bay, renowned for the abundance and diversity of its shellfish. Rivaling its ecological importance for shellfish was its role as a nursery and feeding grounds for countless species of birds and fish. Even in the early 20th century, marshy, estuarine embayments like Jamaica Bay were the driving force behind the soaring productivity of the near shore waters of the mid-Atlantic eastern seaboard.

However, within the past century, the salt marsh community at Gerritsen Creek was altered partially by the dredging and filling activities associated with the construction and maintenance of the Jamaica Bay federal navigation channel and associated improvements related to plans for a new port facility that never came to fruition. Historical records indicate that the Gerritsen Creek

area suffered approximately the same 75 percent wetland loss that Jamaica Bay has been reported to have experienced. The dredging and filling impacts to the marsh associated with channel construction and maintenance were further compounded by landfilling activities associated with the disposal of non-hazardous waste materials in the early part of the 20th century.

Wetland destruction also had negative indirect effects on habitat quality by altering and fragmenting habitats and consequently reducing the ecological value of the remaining tracts of wetland acreage. These remaining estuarine wetlands in the Gerritsen Creek area have been degraded to the point where their ability to provide habitat for numerous species of coastal birds, fish, and invertebrates has been reduced, resulting in a significant disruption to the area's entire interconnected coastal ecology.

2.3 Project Authorization

The Gerritsen Creek ecosystem restoration is being conducted under Section 1135 of the Water Resources Development Act of 1986, as amended. Under Section 1135, the USACE is authorized to review the need for modifications of existing projects for the purpose of providing measures to improve environmental quality. Section 1135 authorizes the USACE to address degradation of the environment caused by a past USACE project.

The original Congressional authorization for a federal channel entering and extending within Jamaica Bay was given in 1910. The existing project area (modified in 1945, 1950 and 1986) provides for 19.5 miles of channel of various width and depth (ranging up to 40 feet deep and 1500 feet wide) consisting of a central entrance channel and two main branches. The construction, maintenance and improvement of the network of channels within Jamaica Bay required the dredging of millions of cubic yards of material; the majority of this material was deposited in nearby wetland areas. The creation of channels and the widening/deepening of channels and basins was performed by the New York City Department of Docks and Ferries, acting as an agent for the USACE. These activities occurred from 1911 through 1945. The existing basins in Jamaica Bay, including Gerritsen Creek, were excavated from large tidal creeks during this period. During the excavation, the majority of the surrounding marshland was bulk-headed and filled with the resulting dredged material.

The USACE has investigated the adverse impacts associated with the construction and maintenance of the surrounding channel system and the subsequent filling that occurred within the surrounding salt marshes, and determined that ameliorative efforts to restore native marsh estuarine communities in the project area are warranted.

2.4 Non-Federal Sponsor

All Section 1135 projects require a non-federal sponsor to provide 25 percent of the cost of any modification and 100 percent of the cost associated with operation and maintenance. NYCDPR is the non-federal sponsor for the Gerritsen Creek ecosystem restoration project. The non-federal sponsor is funding the restoration project in partnership with the New York State Department of Environmental Conservation (NYSDEC) through 50/50 matching funds of the 1996 Clean Water/Clean Air Bond Act and the City of New York.

PART 3 – PROJECT PURPOSE AND NEED

The purpose of the Gerritsen Creek ecosystem restoration project is to ameliorate the adverse impacts associated with the historical construction and maintenance of the Jamaica Bay channel system within the Gerritsen Creek area, with the specific purpose being to improve the environmental quality of this waterway and thereby the overall Jamaica Bay system. This area was altered in the past and, as a result, is less productive than the pre-existing ecosystem habitat. Access to intertidal marshes by juvenile anadromous fish that previously utilized these areas as nurseries and refuge areas has been severely limited. Feeding, nesting, and roosting areas for waterfowl, wading birds, and shorebirds have also been lost. Remnant salt marshes within the Jamaica Bay area are being lost at a significant rate and can no longer provide the quality of habitat for avian and fish species that was provided in their original state. The overall goal of the Gerritsen Creek restoration will be to restore the pre-existing habitat functions by recontouring uplands to intertidal elevations, removing invasive species, and replanting with native species.

The purpose of the Gerritsen Creek Integrated ERR/EA is to evaluate the need for modifying the existing degraded habitat, and determine the solution that maximizes the environmental benefits while minimizing the economic costs. More specifically, the report will:

- Identify existing conditions at the Gerritsen Creek site;
- Assess opportunities and alternatives for the restoration of the degraded ecosystem in the Gerritsen Creek tidal basin;
- Determine the environmental benefits of restoration relative to the economic costs;
- Evaluate the technical, environmental, and institutional feasibility of the federal action to address ecosystem restoration opportunities; and
- Determine if there is local support for implementation of the recommended plan for ecosystem restoration.

PART 4 – PROBLEM AND OPPORTUNITY IDENTIFICATION

4.1 Problem Identification

Even after experiencing significant losses in wetland acreage that have reduced its ecological productivity, the Gerritsen Creek and the Jamaica Bay environs are regionally and nationally important as a coastal resource, in large part because the area still contains a relatively large tract of contiguous habitat. The importance of Jamaica Bay and Gerritsen Creek as critical foraging and staging areas for migratory birds has increased as other coastal wetlands along the eastern seaboard's major migratory route, the Atlantic Flyway, have been filled, drained and fragmented.

The existing tidal marsh communities currently account for approximately 20 percent of the land area on the 67-acre Gerritsen Creek project site. The majority of the remaining area is dominated by *Phragmites*, with areas of trees and shrubs scattered throughout. Most of the *Phragmites*-dominated areas are upland, accounting for approximately 40.5 acres on the site. Most of the upland communities are in early succession and are located within areas of former landfilling.

Field observations indicate that the ecology of the area is severely degraded, primarily due to past activities that included dredging and filling activities. These activities have resulted in the loss of tidal wetlands and open water areas, and the predominance of *Phragmites*. In addition, coastal

processes are adding to the erosion of *Spartina alterniflora* areas along some shorelines, as indicated on the historical aerials provided in Figures 4 (Year 1959) and 5 (Year 1966).

As *Phragmites* becomes more prevalent across the site, other native vegetation is being displaced from the habitat, decreasing the biological diversity. As the biological diversity decreases, the functions and benefits related to water quality, ecological productivity, flood and storm water retention, and aesthetic view sheds will be lost.

4.2 Future without Project Condition

The future without the project condition was determined by projecting conditions in the study area over a 50-year period of analysis (2005-2054). In the absence of federal action, it is anticipated that the degraded condition within the Gerritsen Creek ecosystem (e.g., increasing abundance of invasive species, increasing fragmentation of healthy wetland ecosystems, and continuing erosion within certain areas of the salt marsh) will continue into the future. The site will continue to be used by the public, but environmental quality and view sheds will be lost as the *Phragmites* grows taller (*Phragmites* in some areas of the site were observed to be over 12 feet high) and its rhizomes spread into salt marsh areas currently dominated by *Spartina*-species.

4.3 Goals and Objectives

The federal objectives in making investments in water resource projects are to contribute to the goals contained within the NER plan. The pursuit of planning objectives must be consistent with federal, state and local laws and policies, as well as technical, economic, environmental, and regional, social and institutional considerations. Recommended plans should avoid, minimize and, if necessary, restore adverse project impacts to the environment. They should also maximize benefits, avoid adverse social impacts and meet local preferences to the extent possible.

The primary goals for the Gerritsen Creek site are to restore degraded ecosystems, improve environmental quality, and enhance fish and wildlife habitat. In pursuit of these goals, the following restoration objectives were established:

- Increase biodiversity;
- Restore native habitats;
- Increase habitat diversity with the restoration of tidal channels, open water areas and salt pannes;
- Restore habitat for rare or special-status species;
- Increase tidal flushing within wetland areas;
- Stabilize and protect existing desirable wetland habitats;
- Reduce *Phragmites* invasion and preclude further colonization:
- Promote improved water quality; and
- Maintain and optimize existing educational and recreational opportunities (as a secondary consequence of restoration activities).

There is significant opportunity in the study area for federal action to restore degraded ecosystems, improve environmental quality, and enhance fish and wildlife value, while concomitantly addressing the adverse effects that have occurred historically due to dredging and filling activities within the area.

The predevelopment condition of the Gerritsen Creek area appears to have been tidal marsh and open water, with small islands situated within the embayment area. However, it would not be

feasible to restore the small islands to their original condition due to the amount of excavation that would be required. It is possible to create more ecologically valuable conditions by excavating to elevations that restore the tidal inundation and the original habitat functions associated with the site.

The non-federal sponsor, NYCDPR, is fully supportive of measures to restore the degraded ecosystem. In addition, the New York State Department of Environmental Conservation, the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and the U.S. Environmental Protection Agency (USEPA) support the restoration project.

The Gerritsen Creek ecosystem restoration project will further the goals of the New York/New Jersey Harbor Estuary Program (HEP), a National Estuary Program authorized by the USEPA in 1987. The Gerritsen Creek ecosystem restoration site is a vital component of Jamaica Bay, which HEP has identified as warranting special emphasis for protection and restoration. HEP's primary planning document, the Final Comprehensive Conservation and Management Plan (New York/New Jersey HEP, 1996), includes specific goals which are furthered by the proposed restoration in Gerritsen Creek, such as preserving and restoring ecologically important habitat, and restoring and maintaining communities that support an optimum diversity of living resources, such as fish, wildlife, and plant communities. The Gerritsen Creek ecosystem restoration project also furthers the goals and objectives of the North American Waterfowl Management Plan, an international agreement signed in 1986 that seeks to increase waterfowl populations through increasing and restoring wetland habitat.

In a report entitled *Significant Habitats and Habitat Complexes of the New York Bight Region* (USFWS, 1999), Jamaica Bay was identified in general and Gerritsen Creek in particular as coastal habitats warranting special protection in the form of preservation and restoration of habitats conducive to sustaining and expanding the region's native living resources. The report recognized the area as a highly productive habitat for a variety of fish and wildlife species, particularly certain species of fish which breed in the area and/or use the area as a nursery for juveniles, migratory waterfowl that overwinter in the area, and migratory birds (*i.e.*, shorebirds, raptors, waterfowl, and landbirds) that stop-over in the area during fall and spring migrations. The Jamaica Bay Watershed Management Plan recommended that existing wetland and grassland areas in Jamaica Bay be restored and protected, and invasive species (*e.g.*, *Phragmites*) be controlled. The New York City Audubon Society recognizes the existing undeveloped wetland and upland habitats within Jamaica Bay as vital to the area's continued use by important fish and wildlife species (New York City Audubon Society, 2003).

Although the acreage involved in the proposed restoration at Gerritsen Creek is only a fraction of the acreage that historically existed in the area, the effect of its restoration on the ecological resources of the stressed and degraded Jamaica Bay system will be compounded and complemented by the eventual implementation of other restoration sites in Jamaica Bay currently under study by the USACE, as identified in the Jamaica Bay Navigational Channels and Shoreline Environmental Surveys Report (USACE, 1997). In combination with potential management actions resulting from New York City Department of Environmental Protection's (NYCDEP) Use and Standards Attainment Project improvements to its wastewater treatment facilities that discharge into Jamaica Bay and its combined sewer overflow abatement to improve the overall water quality of Jamaica Bay, the Gerritsen Creek project has the potential to successfully play an important role in significantly improving the environmental quality of the area.

4.4 Planning Considerations

The formulation and evaluation of alternative plans for the Gerritsen Creek ecosystem restoration project incorporated a variety of considerations. The planning constraints used to guide this alternatives analysis are listed below.

Technical constraints included the need for the plans to be:

1. Sound, safe, and acceptable solutions;
2. In compliance with sound engineering practice;
3. Realistic and state-of-the-art;
4. Manageable and maintainable into the future;
5. Consistent with existing local plans; and
6. Complete and not dependent on future projects.

Economic constraints included:

1. The need for restoration features to be efficient (i.e., average annual benefits exceed average annual costs); and,
2. The requirement to conduct a cost effectiveness and incremental cost analysis to identify the plans that would maximize contributions to the NER plan at the least cost ("best buy" plans).

Environmental constraints included the need for the ecosystem restoration plans to be:

1. Evaluated in a watershed context to improve the site's ability to function as self-sustaining systems;
2. Formulated in consideration of the effects of intended and unintended consequences, both on and off of the project site;
3. Formulated in recognition of the attainable restoration state, given the influences of human activities and culturally induced changes in the landscape that are likely to persist and influence system conditions after project completion; and
4. Sustainable.

Regional and social constraints included the need for the plans to:

1. Weigh the interests of state and local publics;
2. Consider the potential impacts of the project on other areas and groups; and
3. Be consistent with existing management plans, especially those of NYCDPR and the adjacent Gateway National Recreation Area.

Institutional constraints included the need for the plans to:

1. Be consistent with existing federal, state and local laws;
2. Be locally supported;
3. Provide public access to the project in accordance with federal and state laws and regulations; and
4. Find overall support in the region and state.

PART 5 – EXISTING CONDITIONS

In the early 1900's, the salt marsh community of Gerritsen Creek was part of the extensive coastal wetland community of Jamaica Bay, renowned for the abundance and diversity of its shellfish and its ecological importance as a nursery and feeding ground for countless species of birds and fish. However, within the past century, the salt marsh community at Gerritsen Creek was altered by the dredging and filling activities associated with the construction and maintenance of the Jamaica Bay federal navigation channel and larger plans for new port facilities. The dredging and filling activities associated with channel maintenance and construction were further compounded by landfilling activities associated with the disposal of non-hazardous waste materials in the early part of the 20th century, including household garbage, and construction and demolition debris.

Wetland destruction caused indirect effects associated with habitat alteration and fragmentation, which further reduced the ecological value of the remaining tracts of wetland acreage and reduced the area's ability to provide habitat for numerous species of coastal birds, fish, and invertebrates, resulting in a significant disruption to the area's entire interconnected coastal ecology.

The purpose of the investigations conducted within the Gerritsen Creek project area was to qualitatively and quantitatively characterize the current conditions and evaluate the potential for restoring the site to a healthy tidal wetland ecosystem. The site conditions that exist today and that were observed during the spring and summer of 2002 are described below.

5.1 Land Use and Zoning

The project site is located in the northeastern section of Marine Park, near the confluence of Gerritsen Creek and Mill Creek, immediately northwest of Floyd Bennett Field. The project site is bordered by the Salt Marsh Nature Center located on Avenue U to the northwest, Gerritsen Creek to the southwest, Mill Creek to the southeast, and the Marine Park Golf Course to the northeast. Gerritsen Creek and Mill Creek are both tidally influenced.

The land uses on the project site are primarily undeveloped parkland (Figure 6), and include passive and active recreation areas heavily utilized by the local community. The natural vegetative communities on site include sandy beaches, fragmented salt marshes, disturbed wetland and upland areas dominated by invasive species, and early successional upland areas. Within the upland area, approximately 80 percent is dominated by *Phragmites*. *Phragmites* is an invasive herbaceous species that grows densely, crowding out other plant species and providing undesirable habitat for most wildlife species. A nature trail, approximately 4,000 feet in length, traverses the site between the marsh areas and the *Phragmites*-dominated upland areas.

The project site is located within the heavily populated neighborhoods of Marine Park and Gerritsen Beach (Figure 7), with the surrounding area dominated by urban land use. The adjacent area is dominated by active and passive recreation land use, and includes playgrounds, walking paths, ball fields and courts, and a public golf course. Adjacent neighborhoods include Mill Island, Mill Basin, Manhattan Terrace and Plumb Beach. These neighborhoods are primarily residential areas, with a mix of light manufacturing, and commercial uses.

The New York City zoning map (Figure 8) indicates that the entire project area lies within a public park, which is not zoned. Within New York City, zoning regulations do not usually apply to public parks.

The park is surrounded primarily by areas zoned for residential use (R4, R5, R3-2) and non-zoned public parkland. The dominant use within the zoned areas is R4, which is a general residence district designed to allow for a broad range of housing types. Areas zoned for commercial and light manufacturing uses are located in small areas nearby.

5.2 Topography and Geology

The Gerritsen Creek site lies within the Southern Long Island watershed, contained within the Coastal Plain Physiographic region. Surficial deposits on Long Island are glacial in origin with morainal deposits to the north and outwash deposits to the south. The surficial deposits form the unconfined aquifer and local water-bearing deposits of lesser extent, including the Jameco aquifer. These systems are underlain by the Magothy and Lloyd aquifers, which are generally confined.

To determine current site topography and bathymetry, the project site was surveyed in the spring of 2002. The survey work was accomplished by conducting multiple profile lines across the site (Figure 9). Twenty-six profiles were surveyed at 100-foot intervals, and in the northeastern section of the site, eight profile lines were surveyed at 200-foot intervals. The distance between surveyed points along each profile was less than 20 feet. The landward portion of the survey was completed using land-based surveying procedures, while the portions of the land that remained inundated were completed via water craft-based surveying. An additional 22 profiles were surveyed in the southeastern tip of the site in late summer 2002. All survey data was collected with enough accuracy to produce topographic mapping with one-foot contours for use by the USACE in further development of the site design.

The final elevations and the estimated one-foot contours developed from the Spring 2002 survey are presented in Figure 10 at a 1" = 300' scale. The horizontal grid for the survey is presented in the Long Island New York State Plane North American Datum 1983 horizontal coordinate system, and the elevations are referenced to the North American Vertical Datum 1988 (NAVD88).

Overall, elevations on site range from a maximum of 24 feet on the existing trail overlook located in the center of the site, to a minimum of –23 feet within the channel of Mill Creek. The average slope in the northwest area is approximately two percent, while in the northeast the average slope is approximately three percent. In general, the sandy beach areas are located at elevations ranging from -2 feet to 0 feet, while the marsh areas along the southeastern edge of the site are located at elevations ranging from 0 feet to 3 feet. The land slopes gradually to the trail, which lies at elevations ranging from 4 to 8 feet along the edges of the marsh. Within the southeastern sections, the land slopes more steeply up to the *Phragmites*-dominated areas adjacent to the golf course. The southwest area, composed primarily of fill material and dominated by *Phragmites*, is located at elevations that range from approximately 3 feet to 16 feet.

Anecdotal evidence suggests that the lowest areas of the channel (measured to a bottom elevation of approximately –23 feet) were created by dredging activities. The highest elevations within the area (a maximum of about 24 feet) exist in the north-central portion of the site and were developed due to the landfilling that occurred on site.

5.3 Soils

The soils in the low lying marsh areas of the site consist primarily of poorly drained organic silts that once existed as the surface layer meadow mat, overlain by sandy material. The sandy

material was likely either dredged from adjacent waterways or eroded from nearby upland areas. The surface layer contains a thin upper layer of root mat and is dominated by emergent marsh vegetation. These soils are inundated twice daily by the tides and have a high groundwater table.

The upland areas, which were historically marshland and open water, were filled in the early 20th century with sandy dredged material, as well as household trash and debris. The surface layer is generally thin and is composed of silty sands or sand. The debris is usually found within one foot of the surface. These upland soils tend to be well drained and are dominated by *Phragmites.*

A geotechnical investigation was conducted to characterize the different soil strata and geotechnical characteristics of the soils located on-site. The investigation was conducted on three separate events: Event 1 occurred on April 25 and April 26, 2002; Event 2 occurred on June 4, 2002; and Event 3 occurred on July 11, 2002. The locations of the subsurface investigations from Events 1, 2, and 3 are illustrated on Figure 11.

Event 1 consisted of seven soil borings (GCB-1 through GCB-7) located along the existing trail and within the areas likely to be excavated for restoration purposes. The soil boring logs indicate that "no recovery" of soil samples occurred at several locations during Event 1. As a result, additional soil borings and test pits were investigated during Event 2. Event 2 consisted of five soil borings (GCB-8 through GCB-12) and nine test pits, located within proposed excavation areas and upland areas. Event 3 consisted of twelve test pits (GCTP-4, GCTP-10, GCTP-12 through GCTP-17a, GCTP-17b, GCTP-18, GCTP-19, and GCTP-20) located approximately 100 feet from the shoreline.

All borings were advanced using hollow stem augers and standard penetration tests. The borings were taken to depths ranging from 12 feet to 22 feet below ground surface. Geotechnical soil sampling was performed at each boring location. The soil boring logs for Events 1 and 2 are presented in Appendix B. Soil samples from the borings were taken for lithologic characterization of the soils and a select number of the soil samples had environmental and geotechnical laboratory testing performed on them. Shelby tube samples were taken from the existing meadow mat. The purpose of the undisturbed Shelby tube samples was to determine whether or not the subsurface material, silty sands, and clays with organic material would rebound after the overburden of the dump material is removed. Results from the consolidation testing performed on the Shelby tube samples (which appear in Appendix B) indicated that the recompression indexes for the soils are relatively low and therefore little rebound is expected to occur.

All test pits were excavated using a rubber-tired backhoe and samples were taken to depths ranging from 5 feet to 10 feet below ground surface. All test pits were lithologically characterized. Soil samples were collected for grain size analysis. The test pit logs and test pit photographs taken during the excavations are presented in Appendix B. Only minor obstructions were encountered during the excavation of the pits.

The geotechnical samples were analyzed for consolidation, swell, salt content and organic matter. These parameters are necessary in helping plan what type of vegetation to plant after construction and what amount of soil augmentation would be necessary and potential rebound of the sub-soil once the over burden is removed.

During Event 2 investigations, it was observed that trash and debris had been placed below ground within the upland areas on site at some indeterminant time in the past. The thickness of the waste ranged from 1 foot to approximately 17 feet. The depth of the waste ranged from 2 to 18 feet below ground surface. The waste material was observed to include primarily glass, plastic,

wood, a few large boulders, tree stumps, and other decomposed material. Below the fill areas is a thin organic layer, which consists of meadow mat and silt or clay material down to 8 to 16 feet below ground surface. A layer of wet, coarse sand was present below the organic layer.

During Event 3 investigations (in the area located near the golf course), no waste material was encountered in the twelve test pits. These pits were observed to contain a thicker organic layer (*Phragmites* and its root mat) within the top three feet below ground surface. Underlying the organic layer was a layer of moist, brown sand. The water table was observed to be approximately six to seven feet below ground surface. The pit walls remained relatively vertical during excavation. No clay layers were encountered. The sand observed in these areas is likely the material dredged from Rockaway Inlet. There were no odors emanating from the pits excavated within this area.

5.4 Water Resources

Jamaica Bay is recognized by the NYSDEC under the State Environmental Quality Review Act as a Critical Environmental Area (CEA). The NYSDEC states that Jamaica Bay and its tributaries, tidal wetlands, and regulated adjacent areas are considered to be a CEA. As a tributary to Jamaica Bay, Gerritsen Creek and its tidal wetlands and regulated adjacent areas are considered as part of this CEA. The NYSDEC defines a CEA as having "exceptional or unique character." The distinct characteristics associated with Jamaica Bay are: 1) a natural setting (e.g., fish and wildlife habitat, forest and vegetation, open space and areas of important aesthetic or scenic quality) and 2) an inherent ecological, geological or hydrological sensitivity to change that may be adversely affected by any change" (NYSDEC, 2003a).

Jamaica Bay is also designated by New York City as one of three Special Natural Waterfront Areas (SNWA). *The New Waterfront Revitalization Program* (New York City Department of City Planning [NYCDCP] 1999b) defines SWNAs as coastal areas with special characteristics identified in New York City's Comprehensive Waterfront Plan that "have particular natural habitat features that should be considered in connection with any waterfront activity." It further directs that "activities that protect and restore these features would be consistent with waterfront policy for these areas."

The New York/New Jersey Harbor Estuary (HEP) program has also recognized the importance of the Jamaica Bay watershed. In the HEP Habitat Workgroup 2001 Status Report (HEP 2001), HEP targeted Jamaica Bay, along with the Arthur Kill and the Hackensack Meadowlands, as one of the three watershed areas "of primary concern and ecological importance."

5.4.1 Regional Hydrology and Groundwater Resources

The Gerritsen Creek site lies within the Southern Long Island watershed, United States Geological Survey (USGS) Hydrologic Unit 02030202. The Southern Long Island watershed has a drainage area of approximately 1,960 square miles and encompasses Kings, Queens, Nassau and Suffolk counties of New York State. Within Kings and Queens counties, the aquifer is not utilized as the sole or principal source of drinking water; however, the geographic boundaries of Kings and Queens Counties are the recharge zone for the aquifers underlying the southeastern portion of Queens County. There are no documented freshwater springs in the area.

Major land uses within this watershed include residential, urban, industrial, commercial, recreational, forested, and coastal areas. Average annual precipitation is approximately 42 inches

and, in general, is evenly distributed throughout the year. The watershed has 625 miles of waterways, consisting mainly of small rivers and streams including the Peconic River.

5.4.2 Surface Water

The low marsh fringes of the 67-acre site are influenced twice-daily by the tides brought in by Gerritsen and Mill Creeks, while the high marsh areas on site receive tidal flushing only during the bi-monthly spring high tides. The remaining areas on site, located at elevations outside of the tidal range, receive inputs primarily from rainwater via overland flow and from a storm drain outfall.

Gerritsen and Mill Creeks are small tidal tributaries that, together with Plumb Beach Channel, drain into Gerritsen Inlet and through Dead Horse Channel, into Rockaway Inlet. The confluence of Gerritsen Inlet with Rockaway Inlet is about three miles from where Rockaway Inlet meets the Atlantic Ocean. Gerritsen Creek runs the length of the site along the southern edge, terminating at Avenue U. Mill Creek flows along the southeastern edges of the site. The water depths in the creek channels are approximately 8 – 11 feet deep, except for the deeper water in small areas of Gerritsen Creek (17 feet mean lower low water) and Mill Creek (about 29 feet MLLW), just to the east and south of the project area. Along the southern coast of the project area, along Gerritsen Creek, the navigation chart (Figure 12) shows very shallow water that may indicate long-term marsh retreat, as well as two pinch points along Gerritsen and Mill Creeks.

Approximately 122 acres of land (including the Gerritsen Creek site) drains through the existing marshes and into Gerritsen and Mill Creeks. This 122-acre drainage area is comprised of two main watersheds divided by a common drainage divide (or ridge line). The drainage divide begins at a high point in the golf course to the north of the site and runs in a southerly direction following the ridge line, terminating at the apex of the bend in Mill Creek. To the west of the divide, a 74-acre watershed discharges surface water runoff through the existing fringe marshes and into Gerritsen and Mill Creeks. To the east of the divide, a 48-acre watershed discharges surface water runoff through the marsh and into Mill Creek. The upper five feet of the soil profile within these run-off areas are composed primarily of sandy material; therefore, there exists a high infiltration potential and a low runoff potential.

Historically, Gerritsen Creek extended inland twice as far as it does today. However, around 1920, the portion of the creek that extended north of Avenue U was converted into an underground storm drain. The watershed for this storm drain comes from the surrounding residential and recreational areas to the north and northwest, and is relatively small. This freshwater drainage is deposited directly into Gerritsen Creek.

During site investigations, a few water samples were taken midday during the low tide on April 9, 2002. The samples were characterized based on temperature, pH, salinity and dissolved oxygen (DO). The results are listed below in Table 1.

The in-situ water quality parameters observed on site are indicative of an estuarine system with relatively high salinity. As expected, results are similar to the water quality of Jamaica Bay as reported in the Jamaica Bay Ecological Restoration and Research Team (JABERRT) studies (Tanacredi et al, 2002). The dissolved oxygen levels reported for the site are above the minimum levels for cold water fish (6.0 g/ml) and estuarine biota (5.0 g/ml).

TABLE 1 – WATER QUALITY SAMPLING RESULTS

	Site 1 – Gerritsen Ck near Nature Center		Site 2 – Gerritsen Ck at inlet to Mill Ck		Site 3 – Mill Creek between White Island & project site		Site 4 – Gerritsen Ck near SW tip of White Island	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Temp. (℃)	11.18	11.11	10.86	10.80	11.00	9.28	11.51	10.97
PH	6.83	7.82	7.93	8.02	8.10	8.15	8.20	8.27
Salinity (ppt)	30.50	30.52	30.52	30.49	30.54	30.34	30.47	30.48
DO (g/ml)	9.07	9.38	9.38	9.43	9.78	9.35	10.66	10.72

5.4.3 Tidal Influences

From March 14, 2002, to May 10, 2002, tidal data was collected in two areas of Gerritsen Creek near the project site. The tidal data collection and results are presented in Appendix C. The locations of the two tide gages located within Gerritsen Creek and the third atmospheric gage located on dry land are shown in Figure 13.

The tidal datum estimated from the two tide gages located in Gerritsen Creek were compared to tidal datum estimated from data collected in the vicinity of the project site in earlier studies and epoch-based datum from the National Oceanic and Atmospheric Administration – National Ocean Service (NOAA-NOS) stations in the vicinity. The comparison is provided in Table 2. The locations of the neighboring tide gages are presented in Figure 13. It should be noted that tidal datum based on observed data may be best used to represent current physical processes, whereas epoch-based datum are best used for long-term considerations and for legal delineation.

Mean high water (MHW) estimated from the two gages in Gerritsen Creek was comparable to the MHW estimated from the closest tide gage, located in Dead Horse Bay and to the epoch-based datum at the NOAA-NOS reference station at Sandy Hook and NOAA-NOS gages at Manhattan Beach-Sheepshead Bay and Marine Parkway Bridge-Barren Island. Mean higher high water (MHHW) estimated from the Gerritsen Creek gages was also comparable to MHHW estimated from observed data at Dead Horse Bay and epoch-based datum at Sandy Hook and Manhattan Beach. However, the mean low water (MLW) and mean lower low water (MLLW) estimated from the Gerritsen Creek gages were lower than corresponding datum estimated from observed and epoch-based datum at the neighboring gages and the reference station.

MLW and MLLW estimated from the Dead Horse Bay gage were unusually high. This was likely due to the fact that the tide gage at Dead Horse Bay was placed in a shallow area where extremely low tides could not be recorded. Therefore, it is likely that the MLW, MLLW, and mean tide level (MTL) datum estimated from the Dead Horse Bay tide gage do not reflect actual conditions.

Table 2 also includes the Sandy Hook Reference Station for the observed period of March 2002 through May 2002. The data was downloaded from the NOAA website at 6 minute intervals for the period March 14, 2002, thru May 10, 2002. The data was converted to NAVD 88, and from this data all of the highs and lows were extracted, then all higher highs and lower lows were extracted.

The differences between MHW and MHHW computed from all tides and MHW and MHHW recomputed from those events without precipitation were approximately 0.20 feet for Gages 1 and 2. The differences for MTL, MLW and MLLW were much less (less than 0.2 feet). Therefore, it is estimated that the precipitation events did not have a great effect on the overall tidal datum estimations.

TABLE 2 – TIDAL DATUM AND RANGES FOR GERRITSEN CREEK AND THE SURROUNDING AREA

	Gerritsen Creek Gage 1	**Gerritsen Creek** Gage 2	**Dead Horse Bay**	**Rockaway Point** Rockaway Inlet	**Marine Pkwy Bridge** Rockaway Inlet	**Marine Pkwy Bridge** Rockaway Inlet	**Manhattan Beach** Sheepshead Bay	**Sandy Hook** Reference Station	**Sandy Hook** Reference Station
	Berger	Berger	USACE	Hydroqual	Hydroqual	Hydroqual	NOAA-NOS	NOAA-NOS	NOAA-NOS
	Observed	Observed	Observed	Observed	Observed	Observed	Epoch	Observed	Epoch
Datum	Mar ’02 – May ‘02	Mar ’02 – May ‘02	Oct ’01 – Nov ‘01	Jul ’88 – Sep ‘88	Jul ’88 – Sep ‘88	Jul ’95 – Jul ‘96	1960 - 1978	Mar ’02 – May ‘02	1960 – 1978
MHWS	3.00	2.82	--	3.39	3.43	3.18	--	--	--
MHHW	2.39	2.12	2.09	2.96	2.90	2.57	2.21	2.20	2.14
MHW	2.11	1.88	2.00	2.57	2.53	2.27	1.95	1.99	1.80
MTL	-0.56	-0.76	0.10	0.06	0.08	-0.35	-0.52	-0.38	-0.53
MLW	-3.22	-3.40	-1.80	-2.44	-2.38	-2.96	-2.99	-2.74	-2.86
MLLW	-3.40	-3.55	-1.82	-2.63	-2.54	-3.19	-3.19	-2.90	-3.06
MLWS	-4.30	-4.56	--	-3.13	-3.09	-3.67	--	----	--
Duration	2 months	2 months	1 month	2 months	2 months	1 year	--	2 months	--
Ranges									
MR	5.33	5.28	3.80	5.01	4.91	5.23	4.94	--	4.66
DR	5.79	5.67	3.91	5.59	5.44	5.76	5.40	--	5.20
SR	7.30	7.38	--	6.52	6.52	6.85	--	--	--

All elevations are in feet and referenced to NAVD88

Datum:
MHWS = Mean High Water Spring
MHHW = Mean Higher High Water
MHW = Mean High Water
MTL = Mean Tide Level
MLW = Mean Low Water
MLLW = Mean Lower Low Water
MLWS = Mean Low Water Spring

MHW, MHHW, MLW and MLLW were also recomputed to account for precipitation events that occurred during the collection time by excluding all data potentially influenced by precipitation events from the calculations. The differences in the original tidal datum versus the recomputed tidal datum are presented in Table 3.

TABLE 3 – COMPARISON OF TIDAL EVENTS WITH AND WITHOUT PRECIPITATION

	All Tides		Tides without Precipitation Events	
Datum	**Gage 1**	**Gage 2**	**Gage 1**	**Gage 2**
MHHW	2.39	2.12	2.19	1.93
MHW	2.11	1.88	1.92	1.69
MTL	-0.56	-0.76	-0.67	-0.88
MLW	-3.22	-3.40	-3.26	-3.44
MLLW	-3.40	-3.55	-3.41	-3.62

In summary, a comparison of the tidal datum from the two gages at Gerritsen Creek with neighboring tidal gages indicates that the tidal datum estimated from the Gerritsen Creek gages are within acceptable levels and can be used for scientific and engineering purposes such as analysis and design.

5.4.4 Coastal Processes

Coastal processes are driven by wind, waves, and currents and promote sediment transport including marsh and channel erosion and accretion. Coastal processes in a tidal marsh are dynamic, resulting in changes to marsh substrate, hydrology, vegetative cover and habitat. Over time, marsh stability is dependent on a balance of sediment agradation and degradation attributable to coastal energies. An understanding of the natural and man-altered coastal processes of the site is instrumental in the restoration design.

Wind and Wave Conditions: The nearest long-term source of wind data for the area is that collected by the U.S. Weather Bureau at La Guardia Airport. For this project, wind statistics for La Guardia are drawn from the North Shore of Long Island Reconnaissance Study. Average wind conditions occurring from the period 1980 to 1989, presented in Table 4, indicate that winds from relevant quadrants, the southeast to the northwest, occur about 58 percent of the time.

Although storms are generally not considered threatening to low-lying marshes (they are submerged during high water, allowing waves to pass over fragile grasses and marsh mats), it is interesting to note that sustained storm winds from the southeast reach 60 miles per hour (mph) about once every two decades.

The wind statistics were analyzed to determine if wind waves are relevant to coastal processes at the project site. Typical fetches range from 500 to 750 feet for virtually all wave approach directions except directly down the creek to the southeast. For those short fetch lengths, the wave prediction methods indicate that average wind-generated wave heights from all directions will be less than 0.15 feet and wave periods are less than one second. Under mean conditions from virtually all directions, wave-driven sediment transport of littoral materials will generally not occur. Storm winds in the five-year return period range (62 mph) across these fetches will generate waves as large as 0.8 feet with 1.5 second periods. Waves of this size are not considered erosive to marshes (generally waves less than one foot are considered to be non-erosive).

TABLE 4 – AVERAGE ANNUAL WIND SPEEDS, LA GUARDIA AIRPORT (1980 - 1989)

Wind Direction	Percent Occurrence	Average Speed (mph)
SE	1.8	10.2
SSE	2.8	9.6
S	10.3	11.0
SSW	5.1	9.7
SW	6.6	10.1
WSW	5.5	10.5
W	7.5	12.1
WNW	8.1	12.3
NW	10.7	13.3

The maximum fetch is directly down the creek to the southeast. Winds from this direction occur only 1.8 percent of the time. For the five-year return period winds along this fetch, estimated at 62 mph, waves could reach 2.37 feet in height with 2.7-second periods. For more typical annual storm wind speed (30 mph), waves are predicted to be 1.0 foot with a 1.8 second period. However, these events are extremely rare given the narrow fetch to the southeast, the two pinch-points located along Mill Creek and Gerritsen Creek, and the low occurrence of winds from that direction. These waves will likely occur with elevated water levels and will have an effect on upland erosion and structural design (as noted by the stone size of the revetment protecting the head of the creek along Avenue U).

Vessel-generated waves occur when a boat travels across the water surface creating bow and stern waves that propagate out from the vessel. The heights of the waves depend on the vessel speed, the boat geometry, and the amount of clearance between the vessel hull and the channel bottom and sides. The waves generated by a vessel decrease with distance from the boat because the waves are very steep and break and because no continuous force (such as wind) maintains the wave height. Assuming that common recreational boats used for water skiing are 20-25 feet in length, about 7-8 feet wide, draw about 2 feet of water, and travel at about 20 miles per hour, the average wave heights generated would be approximately 1.3 feet high about 100 feet from the boat, and decrease to 0.6 feet in height at a distance of 500 feet from the boat. Field observations during the summer of 2002 indicate that the vessel-generated waves from this type of craft created wakes that were less than the erosive 1.0 wave height. However, on occasion, there is the possibility that a boat may pass too close to the shoreline or travel in excess of 20 mph, creating an erosive wave.

Sediment Transport and Erosion Processes: Historical shoreline change for the southern portion of the Gerritsen Creek site was analyzed for the period from 1959 to 2002. The focus of the analysis was the 1,000-foot stretch of shoreline along Mill Creek from the pre-existing bridge to White Island north to where the shoreline curves towards Gerritsen Creek. The objective of this analysis was to determine qualitatively the magnitude of shoreline change occurring within this area of the site, and in particular within the sandy beach area that appears to be receding.

Shoreline change along the project site is related to the dynamics of Gerritsen and Mill Creeks. These dynamics incorporate the combined effects of wind, waves, tides, and current along the shoreline. Wave and current action transports the sediment along the shoreline. Water levels, mainly due to tides and elevated water levels during storms, enhance these effects by increased destructive energy levels. Other geological and coastal developments also shape the present position of the shoreline. Soil type and grain size determines the natural angle of repose and

strength of the soil to resist erosion. Interventions on natural dynamics due to erosion control measures (coastal structures, vegetation, and others) can decrease the recession rate locally while accelerating the rate on the adjacent shorelines. Depending on the availability of the sources in the system, a shoreline may experience both erosion and accretion due to the dynamic forces of the nature. Generally, gain of sediment in a system would translate to shoreline accretion, whereas, loss of sediment would translate into a shoreline recession.

Dynamic shorelines exhibit both short- and long-term variations. Short-term variations can be attributed to seasonal differences in storm intensities, and localized differences in sediment type. Long-term variations (in the order of years) reflect cumulated effects. Short-term rates may be highly variable while long-term effects are averaged.

For the purposes of this analysis, three ortho-rectified aerial images of the site were utilized for the shoreline change analysis, the 1959, 1966 and 2002 aerial photos (Figures 4-6). The erosion/accretion reference features located and mapped on the series of ortho-rectified aerial images were interpreted and compared to two reference features, the waterline and vegetation lines.

The waterline, or the intersection of creek water with beach/land, was selected as the main reference feature used to measure the shoreline change process. This feature is the easiest to map as compared to other features. However, the position of the waterline is entirely dependent on the time that the aerial photograph was taken. That is, comparison of two aerial photos taken at high and low tides could give the impression of erosion or accretion simply as the result of water line position on a beach slope. This could potentially add up to significant errors in horizontal shoreline distance, as measured from the baseline. For example, an error could be as much as 40-60 feet in terms of shoreline location for a near-shore slope of 1:20 (horizontal: vertical) and a 2 to 3 feet difference in tidal water elevation. This assessment was considered during the mapping of the waterline feature.

The other reference feature analyzed, the stable vegetation line, was more difficult to determine, and best judgment had to be applied in early black and white pictures to locate the feature.

Based on the analysis of the reference features in the historical and recent aerial images, the following observations can be made relative the southern portion of the Gerritsen Creek Site:

- The 2002 shoreline is approximately 30 to 40 feet further out into Mill Creek than it was 43 years before in 1959.
- During the period from 1959 to 2002 there was a general trend of accretion along the entire shoreline.
- The 2002 shoreline generally follows the same line as the 1966 shoreline, with the exception of the sandy beach area.
- The sandy beach area has shown a recessionary trend since 1966, with the shoreline receding approximately 50 feet.

Given the wave conditions presented in the previous section, it is assumed that the erosion observed along some sections of Mill Creek results from the following conditions:

- Occasional boat wakes from vessels of sufficient size and speed;
- Upland drainage that carries sediment down the profile to the intertidal zone, which is then carried offshore by tidal currents;

— Very rare large waves that travel directly up the creek toward the project site during periods of high storm surge (winds and waves from this direction only occur about 1.8 percent of the time and the fetch is severely limited in width); and
— Refraction by the abandoned bridge located just off site in Mill Creek.

Longshore sediment transport is estimated to be very small in the traditional sense, as sand movement due to oblique wave energy. Tidal currents, runoff, and discharge into the creek probably generate sufficient ambient current to move very fine materials along the shoreline and down into the nearshore shelf and navigational channel. Cross-shore supplies of sand seem to be available from upland areas due to wind transport, storm runoff transport, and erosion during the rare high wave/high water level event from the southeast.

5.4.5 Floodplains

The project area is located within the floodplain of Gerritsen and Mill Creeks. The extent of the floodplain and associated salt marsh has been greatly reduced as a result of filling. As a result, only the shoreline of the site bordering the creeks is within the floodplain.

The areas located within the channel of Gerritsen Creek are designated by the Federal Emergency Management Agency as Zone AE, which is defined as an area inundated by 100-year flooding for which base flood elevations have been determined (see Figure 14). A narrow band designated as Zone X500 is located adjacent to Zone AE, and is defined as an area inundated by 500-year flooding or an area inundated by 100-year flooding with average depths of less than one foot. The remaining areas on site are designated as Zone X, which is indicative of an area determined to be outside the 100- and 500-year floodplains.

5.4.6 Wetlands

Approximately 18 acres of wetlands currently exist at the project site, and include both high and low marsh areas that exist in various degrees of functionality. To define the elevations of the low and high marsh areas, biological benchmarks were developed in the summer and fall of 2001, and then compared with the tidal analysis results described in Section 5.4.3. To develop biological benchmarks, detailed observations of vegetative communities located on site were collected. These observations illustrate the elevations and tidal regimes under which individual species thrive or struggle, and illuminate the elevations at which undesirable non-native species begin to out-compete target native species.

A summary of the bio-benchmark data is presented in Figure 15. The data utilized to develop the bio-benchmarks are presented in Appendix C. This data, in conjunction with the tidal analysis indicated in Section 5.4.3, identified a range of approximately –1 foot to 4 feet NAVD88 for all marsh areas, with optimal elevations for the establishment of low marsh vegetation between 1 foot and 2 feet NAVD88. An elevation range for sandy beach areas existing below the low marsh areas was determined to be between -2 feet and -1 feet NAVD88.

The MHW mark for the site, identified at approximately 2.0 feet NAVD88, is the elevation that functions as the transition point between the high and low marsh. On the low marsh side of the MHW mark, the marsh is flooded twice per day, while the high marsh side of this elevation is inundated bimonthly. Results of the bio-benchmark study with the tidal datums collected at Gerritsen Creek indicated that results from the tidal analysis strongly concur with the biological analysis.

The low marsh was thus delineated as encompassing approximately ten acres of low marsh, dominated primarily by *S. alterniflora.* The high marsh area was delineated as including two acres of high marsh dominated by salt meadow hay (*Spartina patens*) and spike grass (*Distichlis spicata*) and one acre of high marsh dominated by bayberry (*Myrica pensylvanica*). Approximately five acres of high marsh are dominated by *Phragmites.* These four wetland areas are further defined in the following sections.

Evaluation of Planned Wetlands: The Evaluation of Planned Wetland (EPW) is a method to measure wetland function and value relative to restoration design. The goal of an EPW assessment is twofold: the first part is to evaluate and document the capacity of an existing wetland site to perform specific wetland functions and values; while the second part is to evaluate and document the capacity of a selected restoration plan to perform specific wetland functions and values. To determine the functionality and value of the existing site, current vegetative communities, tidal patterns, sediment types, and human use patterns at Gerritsen Creek were observed, documented, and incorporated into a functional assessment of the existing site using the EPW procedure (Bartoldus et al., 1994). The full assessment results, used to provide baseline information to characterize existing wetland communities, are presented in Appendix D, along with a summary of the EPW methodology, the data utilized in the analysis of the existing site, and accompanying photographs. The analysis of the selected restoration plan is presented in Part 5 of this report.

As previously stated, Gerritsen and Mill Creeks border the existing site. A low marsh fringe is located adjacent to the creeks dominated primarily by *S. alterniflora*, with an adjacent high marsh area dominated in some areas by patches of *S. patens, D. spicata*, and in other areas by *Phragmites* and other high marsh vegetation (including bayberry). The adjacent upland areas have been greatly altered by the placement of dredged and waste fill material.

The urbanized lands that surround the site serve primarily residential uses. The site itself, including the wetland areas, is utilized heavily for passive recreation. Gerritsen and Mill Creeks are both used for recreation purposes (i.e., boating, water-skiing, and fishing). The majority of the site is protected from wind and weather by its position in the landscape: behind White Island, with higher land elevations surrounding it, subject to the calm tidal fluctuations. However, erosion near the abandoned bridge in Mill Creek is evident. Within this area, watercraft tend to speed up and slow down near the abandoned bridge, creating larger wakes than if they were motoring at a steady speed. In addition, refraction from the bridge could create some erosive forces to the project site.

The surface soils on the site are generally composed of an organic silt layer resting on a bed of coarse sand. The wildlife community is typical for this type of upland/wetland complex. The JABERRT studies (Tanacredi et al, 2002) identify bird, fish, and other wildlife species observed using the site.

Based on these site characteristics, the EPW scores indicate that the ten acres of low marsh dominated by *S. alterniflora*, and the three acres of high marsh dominated by *S. patens, D. spicata* and bayberry, possess high functions and values. The high functions and values are related to the shoreline bank stability across most of the site, water quality features provided by the interaction between the tides and the vegetation, and the wildlife and fish habitat provided by the diverse areas. However, within the five acres of high marsh dominated by *Phragmites*, the area has a lower functionality associated with lower water quality and fish habitat (as the tides do not reach into these areas as frequently), and a lack of wildlife habitat related to the dense structure of the *Phragmites* vegetation.

5.5 Vegetation

Several site visits were conducted in the spring and summer of 2002 to document existing marsh and upland habitats at Gerritsen Creek and observe vegetative species. These observations were coupled with information gathered from pre-existing publications, most notably information provided within the JABERRT reports. In general, the natural vegetative communities on the project site include sandy beaches, fragmented salt marshes, disturbed wetland and upland areas dominated by invasive species, and early successional upland areas. A map of existing vegetative communities is presented in Figure 16.

5.5.1 Wetlands

The wetland areas located on site are fragmented, and in parts degraded, as is typical of the Marine Park area. The degraded wetland areas have been impaired and in some cases, no longer function fully. The wetland area is much smaller than it was historically, and sections of the wetland are dominated by invasive vegetative species.

Of the 18 acres of wetlands on the project site, approximately 13 are considered highly functional. Within the highly functional marsh, three distinct habitats exist:

- **Low Marsh**: Defined as the area that lies between elevations –0.83 feet and 2.04 feet NAVD88. Ten acres of narrow fringing areas dominated by *S. alterniflora* currently exist on site.
- **High Marsh**: Defined as the area lying between 2.04 and 2.91 feet NAVD88. Currently, two acres of high marsh dominated by *D. spicata* and *S. patens* occur on site. Other species observed within the high marsh include common glasswort (*Salicornia europaea*) and sea lavender (*Limonium nashii*).
- **Bayberry**: Defined as the transitional area between the highest fringes of the high marsh and the low fringes of the upland area, lying at elevations between 2.91 feet and 4.16 feet NAVD88. Approximately one acre currently exists on site. Located along the edges of the bayberry are small sections of trees, including black cherry (*Prunus serotina*) and sumac species (*Rhus spp*.).

The remaining wetland areas on the site include five acres of low-functioning tidal wetland dominated by *Phragmites*. Although there is a native species of *Phragmites* that historically existed along the mid-Atlantic seaboard, a non-native genus is reported to have become dominant in areas over the past 70 years (Saltonstall 2002). Numerous studies have found that hydrological alterations to tidal wetlands (*e.g*., filling) have contributed to the aggressive spread of the non-native form of *Phragmites*. It has also been noted that once the non-native *Phragmites* becomes dominant within a tidal marsh, the massive root mat causes further hydrological alterations and accelerated sedimentation, both of which will eventually lead to reduced values and functions within the still healthy areas of low marsh.

5.5.2 Uplands

Adjacent to the bayberry areas are small pockets of slightly higher upland areas characterized as maritime grassland. These areas, which cover approximately 0.5 acre of the site, contain a variety of grasses including switch grass (*Panicum virgatum*).

Current upland areas that were historically filled in the past, including the existing trail, the northeastern and central sections of the site, and along the edges of the golf course, are dominated

by *Phragmites*. The *Phragmites* in these areas was observed to be over 12 feet in height. Small pockets of other vegetation were observed within the *Phragmites*-dominated area, including bayberry and sumac species.

Based on observations made in the spring of 2002 and during the geotechnical investigations, the central portion of the site, landward of the nature trail, appears to have been used as a landfill in the past. This area is approximately 20 acres in size. Small trees are scattered across the area, including black cherry, river birch (*Betula nigra*), and sumac species. However, the majority of this area is dominated by *Phragmites*. Due to the ease of public access to the site, this area is often subject to accidental fires. The fires have been observed to occur as often as once every month.

The area located within the northeastern section of the site, approximately 20.5 acres in size, was the site of extensive landfilling in the past. Larger trees are scattered throughout the area, including black cherry, tree-of-heaven (*Ailanthus altissima*), cottonwood (*Populus deltoides*), beech (*Fagus grandifolia*), oak species (*Quercus spp.*), and a number of planted trees; however, this area is also dominated by *Phragmites*. The remaining wooded upland area, approximately 7.5 acres in size, contains many of the same trees found elsewhere on site, including black cherry, tree-of-heaven, cottonwood, beech, oak species, and a number of planted trees. The remaining 0.5 acres on the site are utilized as walking and maintenance trails.

Overall, of the 49 acres of upland on the site, 40.5 acres are a monoculture of *Phragmites*. Within these *Phragmites*-dominated areas that cover approximately 80 percent of the upland area, there exists little variation in vegetative species due to the density with which *Phragmites* grows. This dominance limits the types of habitat and food sources available to wildlife, contributing to the site's lack of biodiversity.

5.6 Fish and Wildlife

Aquatic habitat within Gerritsen Creek and Mill Creek is connected with the larger Jamaica Bay estuary, and as such serves important functions to fish, bird and other wildlife populations. The patches of healthy populations of *S. alterniflora* serve as a nursery area for permanent and temporary resident larval and juvenile fish and reproductive areas for saltwater fish populations and large populations of mussels. The small patches of sandy beaches provide habitat for the reproduction of horseshoe crabs (*Limulus polyphemus*).

The site visits conducted in the spring and summer of 2002 were used to observe wildlife species, particularly birds, utilizing the site. These observations were also coupled with information gathered from pre-existing publications, especially the JABERRT reports. In general, observations of the site agreed closely with the available scientific information.

5.6.1 Shellfish, Finfish and Benthic Resources

Within the JABERRT reports, it was stated that the Gerritsen Creek area supports a healthy and diverse population of juvenile fish species, dominated by killifish (*Fundulus majalis*) and Atlantic silversides (*Menidia menidia*) (Kurtzke and Schreibman, 2002). The authors postulate that this diversity is due to the presence of *S. alterniflora* communities that provide cover for juveniles above the mid-tide level. In addition, the site's physical connectivity to the open waters of Jamaica Bay and the presence of high quality *S. alterniflora* foraging habitat likely provide both refuge from predators and food sources for smaller and young-of-the-year fishes.

In the JABERRT reports, it is noted that although horseshoe crabs have been documented in several locations in the area, they do not appear to use the Gerritsen Creek area for reproductive purposes (Botton and Loveland, 2002). However, as part of this study, horseshoe crabs have been observed using the site. Also, it has been noted that horseshoe crabs engage in reproductive behavior on both sides of Gerritsen Creek, including the sandy beach area on the south end of the site (personal communication, Matt Smith, Salt Marsh Nature Center).

Other reports have noted that the large invertebrate population of mollusks, worms, and crustaceans serve as an important food source to numerous species of fish as well as birds, including nationally important commercial and recreational species such as: winter flounder (*Pleuronectes americanus*), summer flounder (*Paralichthys dentatus*), striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), and, seasonally, the federally-listed endangered shortnose sturgeon (*Acipenser brevirostrum*) (United States Department of the Interior, 1991; United States Department of Commerce, 1993).

5.6.2 Birds

As detailed in the JABERRT reports, Veit et al. conducted a study of birds within the general area of Gerritsen Creek. The study reported that 127 species of birds were recorded in the area. Observations included five of the six salt-marsh dependent species including the clapper rail (*Rallus longirostris*), Forster's tern (*Sterna forsteri*), saltmarsh short-tailed sparrow (*Ammodramus caudacutus*), seaside sparrow (*Ammodramus maritimus*), and boat-tailed grackle (*Quiscalus major*). The study team also recorded eight heron species and a greater diversity of waterfowl and Neotropical migratory land birds in comparison to other JABERRT study areas. However, the area does not support as many migratory shorebirds as other study areas (Veit et al, 2002).

NYCDPR conducted a breeding bird census using spot-mapping techniques in 2000 and 2001, and a waterfowl count during the intervening winter at Marine Park in Brooklyn. Nine species, including clapper rail (*Rallus longirostris*), were confirmed in both years as breeders, using three consecutive observations of a bird singing in the same locality as the minimum for confirmation. A total of 22 possible, probable, and confirmed breeding species were found in 2000, and 17 in 2001. The most abundant breeder in both years was the red-winged blackbird (*Agelaius phoeniceus*). NYCDPR found twelve species of waterfowl using the site during the winter of 2000-2001, including northern pintail (*Anas acuta*). The most numerous species was the Atlantic brant (*Branta bernicla*).

The New York City Audubon Society recognizes Jamaica Bay as one of the prime birding spots in America. Its open bay, salt marsh, upland island, mudflat, brackish, and freshwater habitats are a rich area for wintering waterfowl, migrating shorebirds, wading birds, raptors, and warblers (New York City Audubon Society, 2003).

The Brooklyn Bird Club echoes the Audubon Society's comments in its description of the Brooklyn coast and shoreline as a region within an urban area for migrating birds to land for refueling, rest, and protection within an urban area. The many coves, inlets and inner bays afford waterfowl a safe haven. Buffleheads (*Bucephala albeola*), red-breasted mergansers (*Mergus serrator*), and greater scaup (*Aythya marila*) are numerous here in autumn and winter, while marsh dwellers such as marsh wrens (*Cistothorous palustris*), sharp-tailed sparrows (*Ammodramus caudactus*), and other wading species also inhabit the abundant reeds. During the annual Christmas count, this area usually accumulates the highest species diversity total in Brooklyn. In winter, large populations of brant and Canada geese (*Branta canadensis*) can be

observed. Duck concentrations are quite heavy during the appropriate seasons, usually attaining 20 species annually (Brooklyn Bird Club, 2003).

The club lists the following observed species that it considers scarce or rare: tri-colored heron (*Egretta tricolor*), white-fronted goose (*Anser albifrons*), snow goose (*Chen caerulescens*), lesser scaup (*Aythya affinis*), hooded merganser (*Lophodytes cucullatys*), common goldeneye (*Bucephala clangula*), canvasback (*Aythya valisinera*), Eurasian widgeon (*Anas penelope*), clapper rail, short-eared owl (*Asio flammeus*), bank swallow (*Riparia riparia*), American pipit (*Anthus rubescens*), northern shrike (*Lanius excubitor*), eastern meadowlark (*Sturnella magna*), bobolink (*Dolichonyx oryzivorus)*, and sharp-tailed sparrow (breeding population only) (Brooklyn Bird Club, 2003).

Previous USACE reports have reported that more than 300 species of birds currently utilize the Jamaica Bay area, including a variety of species of herons, ducks, geese, plovers and sand pipers (USACE, 1994). Notably, Jamaica Bay provides nesting and foraging habitat for the federally-listed threatened piping plover (*Charadrius melodus*) and federally-listed endangered roseate tern (*Sterna dougalli dougalli*).

5.6.3 Mammals, Reptiles and Amphibians

As detailed in the JABERRT reports, Burke & Ner surveyed mammals, reptiles, and amphibians within the Gerritsen Creek area. Several species of rodents were documented using the area, as well as a typical urban complement of mammals, such as raccoons (*Procyon lotor)*, gray squirrel (*Sciurus carolinesis*), opossums (*Didelphis virginiana*), eastern cottontails (*Sylvilagus flordianus*), meadow voles (*Microtus pennsylvanicus*), feral dogs (*Canis familiaris*), and cats (*Felis silvestris*). Reptiles recorded were the diamondback terrapin (*Malaclemys terrapin*) and brown snake (*Storeria dekayi*). No amphibians were recorded on the site (Burke & Ner, 2002). None of the species documented in this study are legally protected in New York State.

5.6.4 Rare, Threatened, Endangered and Special Concern Species

All appropriate federal and state agencies were consulted regarding the documentation of rare, threatened, and endangered species and species of special concern within the project site and adjacent areas. The USFWS and NMFS were contacted regarding federally-listed threatened and endangered species, while the NYSDEC, Division of Fish, Wildlife, and Marine Resources was contacted regarding state-listed species. Correspondence with these agencies can be found in Appendix E.

Federal Species: The USFWS stated, "no federally-listed or proposed endangered or threatened species under our [USFWS] jurisdiction are known to exist in the project impact area." The NMFS stated, "pursuant to the Endangered Species Act…There are no endangered or threatened species in the *immediate* project area." Copies of USFWS and NMFS letters are presented in Appendix E.

The NMFS also stated that "pursuant to the Fish and Wildlife Coordination Act… the following may be present in the project area: anadromous and resident fish, and forage and benthic species." The NMFS suggested contacting the appropriate Regional Office of the NYSDEC to confirm the presence of anadromous or resident aquatic populations.

State Species: At the time this report was finalized, the NYSDEC had yet to provide information regarding the presence of rare, threatened, and endangered species at the project site.

5.6.5 Essential Fish Habitat

The regional fisheries management councils, with assistance from NMFS, are required under the 1996 amendments to Magnuson-Stevens Fishery Management and Conservation Act to delineate Essential Fish Habitat (EFH) for all managed species, minimize to the extent practicable adverse effects on EFH caused by fishing, and identify other actions to encourage the conservation and enhancement of EFH.

EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity" (NMFS, 2003). In addition, the presence of adequate prey species is one of the biological properties that can define EFH. The regulations further clarify EFH by defining "waters" to include aquatic areas that are used by fish (either currently or historically) and their associated physical, chemical, and biological properties; "substrate" to include sediment, hard bottom, and structures underlying the water; areas used for "spawning, breeding, feeding, and growth to maturity" to cover a species' full life-cycle; and "prey species" as being a food source for one or more designated fish species (NMFS, 2003).

NMFS was contacted regarding the documentation of EFH within the project site and adjacent areas. The NMFS stated that "pursuant to…the Magnuson-Stevens Fishery Conservation and Management Act" that "The project area has been designated as EFH for one or more species." The full EFH assessment is found in Appendix F.

5.7 Socio-Economics

Although the project site is located within Community Board 18, Community Board 15 lies adjacent to the project site. Therefore, information regarding socio-economics (based on Year 2000 Census) was obtained for both Community Boards 15 and 18, and is presented below.

5.7.1 Population

Based on Year 2000 census data, the population of Community Board 15 was estimated at 160,319, which was an 11.7 percent increase from 1990 census data (NYCDCP, 2002). In Community Board 18, the population was estimated at 194,653, a 19.8 percent increase from 1990 census data. In contrast, the total population for New York City was estimated to be 8,008,278, representing a 9.4 percent increase over 1990 census data, while Brooklyn population was estimated to be 2,465,326, representing a 7.2 percent increase over 1990 census data. Brooklyn is the largest borough in terms of population, encompassing 30.8 percent of the city's population

5.7.2 Economy and Income

After the longest period of employment gain ever recorded (1993-2001), New York City's economic expansion slowed after September 11, 2001 (NYCDCP, 2001). Prior to that event, the City had regained the 312,400 private-sector jobs it lost in the recession, from 1987 (3,009,600) to 1992 (2,697,200). By 2000, private-sector employment for New York City stood at 3,152,600.

Within Community Board 15, median household income was estimated in 2000 to be $37,450, while in Community Board 18 it was estimated to be $48,085 (NYCDCP, 2000). In contrast, median household income for Brooklyn in 2000 was estimated to be $32,640, while the total for New York City was estimated at $41,720. Out of the 59 community boards that have been set up

across the city, Community Board 18 was ranked 14th in income in Year 2000 and Community Board 15 was ranked 27th.

5.7.3 Housing

Residents of Brooklyn, like the rest of New York City, are more likely to be renters, to live in compact neighborhoods, and to travel on mass transit. In general, both commercial and residential districts are built to high densities and the opportunity for new housing is limited.

However, some new housing development continues to take place. According to the NYCDCP, the number of new housing units for all of New York City fell by 14 percent from 1998 to 1999, although the number of new housing units were still almost 22 percent greater in 1999 than in 1995 (NYCDCP, 1999a). The greatest decline in new housing numbers occurred in Brooklyn, with a drop of 37 percent from 1995 to 1999.

In FY 2001, a total of 3,570 gut rehabilitation and new construction units occurred within New York City, and 8,984 moderate rehabilitation units were started, leading to a total of 12,554 units of governmental assisted housing (NYCDCP, 1999a). The decline in the number of city-owned vacant buildings has continued from 1,763 in FY 1994 to 633 in FY 2001, as a result of the city's continuing success in rehabilitating its vacant buildings and returning them to the private sector. Individual statistics for Brooklyn were not available.

5.8 Cultural Resources

A Phase 1A Cultural Resource Documentary Study was performed for the Gerritsen Creek site. The study involved background documentary research and a field inspection. The purpose of this work was to provide an assessment of the site's archaeological and cultural resource potential.

No previously documented prehistoric or historical archaeological resources were noted within the project area. Based on historical references, and taking into account the extensive land modification that resulted from the creation of Marine Park in the mid-twentieth century, there is only a slight potential for intact Native American and historical remains surviving within the project area. A summary of the study findings is presented below, while the full archaeological report is presented in Appendix G.

The New York State Historic Preservation Office (SHPO) was contacted regarding the effects of the project upon cultural resources. SHPO reported that the project "will have No Effect upon cultural resources in or eligible for inclusion in the National Registers of Historic Places." A copy of this letter is presented in Appendix E.

5.8.1 Prehistoric

Although the overall Gerritsen Creek area remains archaeologically sensitive to both Native American and historic remains, there does not appear to be a high sensitivity in the proposed project area. This determination was based on the gathered historical documents and maps, previous archaeological fieldwork, pedestrian survey, test pits excavated as part of the Hazardous, Toxic, and Radioactive Waste (HTRW) study and oral history.

Based on historical references, information gathered from the Geotechnical/HTRW soil investigations, and taking into account the extensive land modification that resulted from the creation of Marine Park in the twentieth century, it was determined that subsurface field testing

would not be required. The New York State Office of Parks, Recreation and Historic Preservation supported this determination.

5.8.2 Historic

No standing historic structures are present within the project area. The remains of the former Gerritsen's Tidal Grist Mill, associated dams, a walkway pier and the Avenue U wooden footbridge are present outside of the project area on the opposite side of Gerritsen Creek, across from the project site.

5.9 Coastal Zone Management

The project site is located within the Coastal Zone Boundary of New York City, as indicated on the 1982 sectional maps delineating the boundaries of New York City's coastal zone included in *The New Waterfront Revitalization Program.* As a federally funded project located within the New York City coastal zone, the proposed project must be reviewed by the New York State Department of State for consistency with the policies of the New York State Coastal Management Plan (NYS CMP) and the applicable local New York City program, *The New Waterfront Revitalization Program.* All information related to the coastal consistency application is presented in Appendix H.

5.10 Hazardous, Toxic and Radioactive Waste

An environmental investigation of the soils located on the Gerritsen Creek site was undertaken on April 25, 2002. A total of nine soil samples (GCHA-1 through GCHA-9) were collected, using a hand auger, from wetland areas located between the shoreline and the existing nature trail. The hand auger locations are presented on Figure 6. All samples were collected at a depth of approximately 1.5 feet below ground surface.

The Fort Monmouth Environmental Testing Laboratory conducted the laboratory testing. The results of this investigation are presented in the Analytical Data Report in Appendix B.

All soil samples were analyzed for Volatile Organics + 15 Library Search, Pesticides/ Pesticides/Polychlorinated Biphenyls (PCB), Resource Conservation and Recovery Act (RCRA) Metals, pH, and percent moisture. Table 5 presents a comparison of the results with the NYSDEC Technical and Guidance Memorandum (TAGM) #4046 Recommended Soil Cleanup Objectives and Cleanup Levels (NYSDEC 1994). Based on this comparison, only Sample GCHA-3 exceeded the NYSDEC TAGM criteria for cadmium at 2 feet below ground surface.

The analytical result for cadmium (1.94 mg/Kg) in Sample GCHA-3, while exceeding the NYSDEC TAGM of 1 mg/Kg, can be discounted as statistically insignificant, since cadmium is a naturally occurring metal and is present in all of the field samples.

The analytical results for Volatile Organics produced no findings other than for acetone and an unknown compound, which appeared in all nine samples. The presence of acetone, at the levels detected, can be attributed to laboratory cleaning procedures. The concentrations of the detected unknown compounds were estimated by the laboratory and are far below levels that would be of concern.

Pesticide/PCB analytical testing indicated no detectable compounds in all nine samples.

TABLE 5 – SUMMARY OF DETECTED ANALYTES IN SOIL

Sample ID	NYSDEC	TB	GCHA-1	GCHA-2	GCHA-3	GCHA-4	GCHA-5	GCHA-6	GCHA-7	GCHA-8	GCHA-9
Lab Sample ID	TAGM	2022901	2022902	2022903	2022904	2022905	2022906	2022907	2022908	2022909	2022910
Sampling Date	RSCOs	4/25/02	4/25/02	4/25/02	4/25/02	4/25/02	4/25/02	4/25/02	4/25/02	4/25/02	4/25/02
Matrix		Aqueous	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (ft bgs)			1.5	2	2	4	4	1.5	1.5	6	4
Volatile Organics		Result Q	Result Q	Result Q	Result Q	Result Q	Result Q	Result Q	Result Q	Result Q	Result Q
Acetone	200	2 U	**23**	**23**	**24**	**6**	**13**	16 U	**6**	**22**	**60**
2-Butanone	300	3 U	4 U	4 U	**27**	4 U	4 U	**2 J**	4 U	4 U	**2 J**
Unknown TIC	10,000	0 U	**103 J**	**111 J**	**145 J**	**25 J**	**63 J**	**131 J**	**24 J**	**84 J**	**111 J**
Total VOCs	10,000	0 U	**126**	**134**	**196**	**31**	**76**	**133**	**30**	**106**	**173**
RCRA Metals (mg/Kg)		Result Q	Result Q	Result Q	Result Q	Result Q	Result Q	Result Q	Result Q	Result Q	Result Q
Arsenic	7.5	NT	**1.22**	**1.38**	**1.31**	**1.28**	**1.09**	**0.956**	**0.897**	0.516 U	**1.49**
Barium	300	NT	**4.77**	**3.80**	**16.6**	**10.4**	**3.58**	**3.66**	**3.73**	**7.94**	**5.80**
Cadmium	1	NT	**0.416**	0.126 U	**1.94**	0.109 U	0.123 U	0.128 U	0.122 U	0.129 U	0.127 U
Chromium	10	NT	**5.04**	**4.46**	**3.25**	**3.08**	**4.15**	**3.28**	**3.16**	**3.83**	**3.57**
Lead	4*	NT	**2.00**	**3.97**	**2.16**	**1.74**	**1.31**	**1.25**	**1.40**	**1.80**	**1.50**
Selenium	2	NT	**1.11**	0.758 U	**1.79**	**1.36**	**0.750**	**1.19**	**1.12**	0.774 U	**1.25**
General Chemistry		Result Q	Result Q	Result Q	Result Q	Result Q	Result Q	Result Q	Result Q	Result Q	Result Q
PH	NC	NT	6.13	7.11	7.38	8.02	7.58	6.69	7.16	7.65	7.31
Moisture (%)	NC	NT	20.83	25.27	26.10	19.48	23.61	23.71	22.40	22.64	24.24

Notes:
Samples collected by the USAE and analyzed by Fort Monmouth Testing Laboratory
Samples analyzed for VOA+15, PEST/PCB, RCRA Metals, pH, % Solids
Analytes not listed were under detection limits
Bold values indicate detections above maximum detection limits
Bold and shaded values indicate exceedances of NYSDEC Criteria
NT = Not Tested
NC = No Criteria set by NYSDEC
Q = Qualifier
U = Not Detected
J = Estimated

NYSDEC TAGM RSCOs = NYSDEC Technical and Administrative Guidance Memorandum #4046 Recommended Soil Cleanup Levels, 1/2/94
* = site background, NYSDEC TAGM states typical site background levels for lead of 4 to 61 mg/kg (rural) and 200 to 500 mg/kg (urban)
ug/kg = micrograms per kilogram, dry weight basis
mg/kg = milligrams per kilogram, dry weight basis
ft bgs = feet below ground surface

To complement the data provided by the field investigations, a review of the literature provided in the JABERRT study was conducted. The results indicated that elevated concentrations of total PCBs occurred in the vicinity of Gerritsen Creek in the year 2000. However, the sample was not actually taken on the Gerritsen Creek site and the concentrations appeared to diminish in the year 2001. All of the analytical results for the field samples taken at the Gerritsen Creek site in 2002 were non-detectable for PCBs and pesticides.

Based on a review of the analytical results and considering only one soil sample out of nine exceeded the NYSDEC criteria, it is determined that the soils present on the Gerritsen Creek site are suitable for the ecological restoration goals and re-use on site.

The channels adjacent to the project site and the areas of Jamaica Bay are used primarily for recreation purposes (i.e., boating, fishing) rather than for commercial shipping.

5.11 Navigation

Navigation near the project site is limited to the Gerritsen and Mill Creek channels. Gerritsen Creek, Mill Creek and Plumb Beach Channel flow together into Gerritsen Inlet and through Dead Horse Channel into Rockaway Inlet. The confluence of Gerritsen Inlet with Rockaway Inlet is about three miles from where Rockaway Inlet meets the Atlantic Ocean.

The water depths in the creek channels are approximately 8 – 11 feet deep, except for the deeper water in small areas of Gerritsen Creek (17 feet MLLW) and Mill Creek (about 29 feet MLLW), just to the east and south of the project area.

5.12 Aesthetics and Scenic Resources

The existing project site provides approximately 60 acres of open space within a highly urbanized setting. The site is located within Marine Park, and provides passive and active recreational uses as well as viewsheds of the surrounding area. A walking trail weaves through the project site. The shoreline runs parallel to sections of the trail and is accessible to the public. *Phragmites* lines the trail, and typically reduces visibility so that the shoreline is not visible from the trail except where the trail rises to an elevation of approximately 24 feet. At this high spot, views of the surrounding open space and neighborhood are provided. Occasionally, fires occur on site, burning down the tall stalks of *Phragmites* and opening up the viewshed to the shoreline, creeks, and surrounding area.

There is a significant amount of disturbed areas within the project site due to long-time, unauthorized disposal of household waste and construction and demolition debris on site and in the surrounding open space areas. A thin layer of sandy material covers most of the waste. However, some boat and car frames have either been disposed of onsite or have floated in with the tides. The ground in some areas is heavily littered with miscellaneous debris.

5.13 Recreation

As with the other areas of Marine Park and the Gateway National Recreation Area, the project site provides opportunities for passive and active recreational uses. The nature trail provides opportunities for walking and bird watching, and provides access to shoreline areas for fishing and wildlife viewing. Adjacent to the project site, recreational opportunities are provided at the nature center, golf course, and playground. Across Avenue U, within other areas of Marine Park,

are walking trails, open spaces, and baseball fields. Within the creeks, there are opportunities for boating, fishing and water skiing.

5.14 Transportation

Land: Vehicular access to the site is provided via a system of collector and arterial roads. Truck routes include Flatbush Avenue (a through route) and Avenue U (a local route). The Belt Parkway, a limited access arterial open to non-commercial traffic only, runs along the western and southern edges of Brooklyn providing access to the Jamaica Bay area.

Air: Air-based transportation is accessible at JFK International Airport, located approximately ten miles east of the project site.

Subway: The BMT Q (Brighton) Line operates between Manhattan and Sheepshead Bay/Brighton Beach in Brooklyn. The Q line runs along E 16th Street, located approximately 1.5 miles west of the project site. Subway stops are located at Kings Highway, Avenue U, and Gravesend Neck Road.

Buses: New York City Transit provides bus service to the project area on the Q35 line which operates along Flatbush Avenue between Midwood and Rockaway Park, on the B3 line which operates along Avenue U between Bensonhurst and Bergen Beach, and on the B46 line which operates along Utica Avenue between Kings Plaza and Williamsburg. Triboro Coach Corporation also provides bus service on the B2 line (between Kings Highway Station and Kings Boulevard), by Queens Surface Corporation on the B31 line (between Gerritsen Beach and Kings Highway Station) and B41 line (between Kings Plaza and Downtown Brooklyn), and by Jamaica Buses Inc. on the B9 line (between Flatlands and Kings Plaza).

5.15 Air Quality

The project is located in an ozone non-attainment area under the Clean Air Act with a conformity threshold value of 25 tons per year of nitrous oxide (NOx) and ozone precursors.

5.16 Noise

Noise is generally defined as unwanted sound, and sound is defined as any changes in air pressure at a frequency that the human ear can detect. Human beings can detect a large range of sound pressures ranging from 20 to 20 million micropascals, but only those air pressure variations occurring within a particular set of frequencies are experienced as sound. In terms of hearing, humans are less sensitive to low frequencies (<250 Hertz [Hz]) than mid-frequencies (500 – 1,000 Hz). Humans are most sensitive to frequencies in the 1,000 to 5,000 Hz range. Since ambient sound contains many different frequencies all mixed together, measures of human response to sound assign more weight to frequencies in this range. This is known as the A-weighted sound level.

Noise criteria and the descriptors used to evaluate project noise are dependent on the type of land use in the vicinity of the proposed project. In general, land uses near the project site include residences and institutional uses (schools, places of worship, libraries). Receptors within the vicinity of the site include the nature center and the golf course. There are no highly sensitive receptors (i.e., hospitals) located within the immediate vicinity of the site.

The primary sources of ambient noise in the project area include auto, truck and bus traffic along Avenue U and Flatbush Avenue, auto traffic on the Belt Parkway, and air traffic to and from JFK Airport. Other noise sources include boats in the creeks (in the warmer months of the year), park maintenance activities (i.e. lawn mowing), and local construction activities.

Although noise levels for the project area have not been measured, they can be approximated based on the existing land use, which is primarily residential and open space. The typical noise level in residential areas ranges from 39 to 59 dBA (decibels on the A weighted scale) (USEPA, 1978). It can be assumed that these noise levels are within the low range of noise levels within this urbanized area.

PART 6 – PLAN FORMULATION, EVALUATION AND SELECTION

A small fringe of healthy tidal wetlands exists on site, and larger areas of healthy tidal wetlands exist nearby within Marine Park and Jamaica Bay. Therefore, it is likely that the disturbed areas within the project site that received fill in the past can be restored to healthy tidal wetland ecosystems.

To achieve this objective, the proposed project will restore approximately 35.5 acres of habitat, including approximately 20.5 acres of intertidal salt marsh and approximately 15 acres of coastal/maritime grassland. In this context, the concept of "restoration" is used as defined by the National Academy of Science's National Research Council: the reestablishment of predisturbance aquatic functions and related physical, chemical, and biological characteristics (National Research Council, 1992). The proposed restoration will be accomplished through a combination of excavation, placement, recontouring, and native species' plantings.

The restoration activity at Gerritsen Creek will significantly expand the small area of existing relatively high quality salt marsh that borders the open water. *Phragmites* has encroached on the salt marsh, and the growth of the root mat has caused the topographic elevations within the area to rise above the normal range of tidal inundation. As such, the primary mechanism to restore and expand salt marsh habitat and thwart future *Phragmites* encroachment is to excavate those areas dominated by *Phragmites* located above the mean high water line down to the levels of intertidal marsh (defined as areas between mean tide level and mean high water). Based on the tidal analysis performed for this report, the optimal elevation for the establishment of low marsh vegetation is at 2 feet NAVD88, which is the highest elevation low marsh is currently found.

The excavation, regrading, and recontouring used to create the intertidal salt marsh system will establish an elevational gradient that gradually transitions from open water to wetland – that is, wetland vegetation (primarily *S. alterniflora*) will occupy a gentle slope of increasing elevation. At low tide, mudflat areas will be exposed along the edges of the interface of the salt marsh and the open water area; at high tide, the mudflat and salt marsh will be flooded at varying depths, depending on its elevation. In addition, the existing fringes of tidal marsh adjacent to Gerritsen Creek and Mill Creek will continue to function as a result of overland sheet flow.

As the fringe of tidal marsh is restored to a much wider expanse of marshland, a system of tidal creeks will be added to facilitate tidal flushing. Intermittent, secondary tidal channels will be developed using site-specific hydrologic, hydraulic and sedimentary conditions to mimic a natural dendritic pattern of tidal channels. The goal for creek placement will be to allow for optimal inundation periods, which is typically defined for a tidal marsh with slopes of one percent, to be no further than 200 feet from any channel or creek. In this way, salt marsh species like *S.*

alterniflora growing in the uppermost portions of the restored wetland will receive the appropriate degree and magnitude of tidal flushing necessary for their long-term sustainability.

The successful expansion of the existing fringe marsh relies primarily on establishing, with a high degree of accuracy, the correct elevations for intertidal salt marsh. The necessary level of accuracy has been determined by carefully measuring the elevations of nearby fringing marshes through biobenchmarking techniques that established the range of elevations certain plant communities occupy. These elevations were presented in Section 5.4.6 and illustrated on Figure 15. This information was then compared and combined with the tidal data analysis to determine a general elevational goal of 2 feet NAVD88.

The entire area to be excavated to intertidal wetland elevations was determined in conjunction with the topographic survey data developed for this project so that the total volume of excavated material would be kept to a minimum, thus minimizing excavation and disposal costs. In addition, after landfill material was uncovered during the geotechnical investigation, a new alternative was developed to avoid excavation within known areas containing landfill material to minimize costs and regulatory procedures associated with the off-site disposal of landfill waste.

Areas that have not been filled with waste consist primarily of *Phragmites* root mat and sand. The root mat material will be re-used on site within the existing *Phragmites*-dominated areas outside of the existing trail loop. Sandy material will be re-used in the area within the existing trail loop to create a coastal/maritime grassland community. Coastal grassland communities in Jamaica Bay currently occupy a tiny percentage of their historical range. In this way, the project would generate ecosystem restoration benefits for both coastal salt marsh and coastal grassland communities.

Unlike intertidal salt marsh, the creation of coastal grassland habitat does not require precise elevation data. Instead, successful restoration requires specific soil physical and chemical characteristics. Soils need to be predominately (greater than 80 percent) coarse to medium sands or gravels and contain low levels of nutrients (particularly nitrogen and phosphorus concentrations) (USACE, 1997). The surface substrate and sub-grade must be well drained to prevent wet depressions that would provide desirable conditions for *Phragmites* to reestablish.

The habitat value of native grassland, containing warm season grasses like dune grass (*Ammophila breviligulata*), switchgrass, and little bluestem (*Andropogon scoparius*), is significantly higher to native animal species than non-native herbaceous species adapted to disturbed soil conditions (USACE, 1997). A diversity of native flowering herbaceous species will be added to the grassland seed mix since there are few local sources for natural recruitment. Although standard and successful techniques to establish warm season grassland habitat exist, most species have a small seeding window (approximately the month of May) and establish themselves relatively slowly, so maintenance activities are often necessary during the first two or three years after planting (Dickerson et al., 1989; Gaffney and Dickerson, 1987).

6.1 Alternative Restoration Plans

To meet the design objectives stated above, four alternatives were developed to restore the Gerritsen Creek project area. These restoration alternatives were developed based on design guidelines developed at a series of team design meetings. Originally, eight restoration alternatives were developed. From these eight alternatives, three were selected for further development and analysis based on how each alternative met project objectives and cost limits. The five rejected alternatives were assessed as not meeting project goals and objectives. These preliminary

alternatives, labeled Alternatives 1, 2 and 3, are presented in Figures 17, 18 and 19, respectively. A fourth alternative was developed later after the geotechnical investigation indicated that certain areas designated for excavation under Alternatives 1-3 contained waste material. Due to the economic and regulatory constraints presented in excavating former waste materials, a new alternative that avoided the waste-filled areas was developed. This alternative incorporates lands owned by NYCDPR that were not included within the original project site. The fourth alternative is presented as Figure 20.

All four restoration alternatives were designed to accomplish three main goals: restore tidal flow in several areas around the site, create a native grassland meadow in adjacent upland areas, and promote overall ecological diversity while preserving the desirable natural areas and passive recreation uses that currently exist on site. To achieve these goals, the four restoration alternatives include the following design elements:

- Creation of meandering channels that branch into the project site in a manner typical of natural salt marsh tidal networks;
- Excavation of previously filled areas down to elevations that can support a tidal marsh system;
- Maintenance and enhancement of existing healthy tidal marsh systems;
- Stabilization of slopes by relocating the nature trail inland;
- Deposition of excavated fill material within the center of the nature trail;
- Treatment and revegetation of the barren areas located by the existing pedestrian bridge; and
- Replacement of invasive dominant vegetation with native tidal and coastal plant species.

In general, all four restoration alternatives would increase the amount of marsh from about 12 acres of high and low *Spartina*-dominated marsh to more than 30 acres of high and low *Spartina*-dominated marsh, while creating approximately 15 acres of coastal grassland community.

The specific design elements associated with each restoration alternative are discussed below.

6.1.1 Alternative 1

Alternative 1 utilizes only the 46 acres of project area located southwest of the golf course. The existing high marsh within this area is approximately 2 acres while the low marsh is approximately 6 acres.

Alternative 1 contains provisions for excavating two sinuous intermittent channels on the southeast side of the site from Mill Creek well into the eastern side of the site, bringing tidal flushing into areas that currently do not have such regular exchanges. The total new channel length would be over 3,200 linear feet. The channels would have a bottom elevation of -1 feet and bottom width of 6 feet, and 3:1 slope to a top width of 18 feet.

The areas within the eastern section would then be graded down to elevations that can support a low marsh system. The existing low marsh has been delineated to occur between elevations –0.83 feet and 2.04 feet NAVD88. The restored low marsh will be located on the upland side of the existing low marsh. Therefore, targeted elevations for the restored low marsh will be the higher elevations of the existing low marsh, approximately 2 feet NAVD88. Existing tidal systems along the northeastern side of the site would be maintained at their existing elevations, while the *Phragmites*-dominated areas would be graded down to elevations more supportive of *S.*

alterniflora populations. The low marsh areas will slope at a one percent grade to the high marsh areas, which will be constructed at elevations of approximately 4 feet NAVD88. The high marsh area will be set on a 3:1 slope to reduce the area available for *Phragmites* re-invasion.

The existing nature trail would be moved inland to optimize marsh acreage and improve slope stability from the low marsh up to the upland areas. The southeastern tip of the trail would be removed and a graded down to marsh elevations of approximately 3 – 4 feet NAVD88.

A second trail would be developed that follows the change in elevation up the hill, allowing access to a new overlook with a view of the marsh and creeks. A boardwalk, created with materials similar to the existing bridge located near the Nature Center, would be built across the low marsh area and around the creek side of the bayberry colonies located there. This feature would allow visitors the opportunity to observe a functioning low marsh area without disturbing it. The area around the bayberry colonies would be graded down slightly to lower elevations, reducing the overall size of the colony.

The newly created marsh areas (approximately 17.5 acres in size) would be planted with a mix of *S. alterniflora*, *S. patens*, *D. spicata*, and other native tidal marsh species. The transition slopes would be stabilized with a salt-tolerant seed mixture and planted with small salt-tolerant shrubs.

All materials excavated from the eastern, southeastern and northwestern areas that can be reused on site will be placed within the upland areas located within the nature trail creating a restored grassland area of approximately 18 acres in size. Approximately three feet of sand would be placed overtop the excavated materials. The elevation of the trail in this area will increase, along with the surrounding areas. Excavated materials that can not be reused on site will be disposed of in a permitted landfill.

The overall acreage of marsh and channels would be approximately 26.5 acres in size, with newly restored marsh areas approximately 17.5 acres in size. Based on order of magnitude estimates prepared for the preliminary designs, the total excavation quantities for Alternative 1 were estimated to be approximately 145,800 cubic yards and total cost for construction to be approximately $15 million. The cost for construction is largely driven by the costs related to the off-site disposal of landfill material, as much of the area proposed to be excavated under Alternative 1 is currently composed of trash and debris and therefore could not be reused within the coastal grassland area.

6.1.2 Alternative 2

Alternative 2 also utilizes only the 46 acres of project area located southwest of the golf course, and as such consists of 2 acres of high marsh and 6 acres of low marsh prior to any restoration activities.

Alternative 2 also proposes the excavation of two channels. However, one of these channels would enter the site from Mill Creek as in Alternative 1 and travel well into the eastern area, while the other channel system would enter from Gerritsen Creek on the southwestern side of the site. This would allow for greater tidal flushing within the newly created marsh in that area. The total channel length under Alternative 2 would be over 3,500 linear feet. The channels would have a bottom elevation of -1 feet and bottom width of 6 feet, and 3:1 slope to a top width of 18 feet.

Under Alternative 2, the existing nature trail would again be moved inland to optimize marsh acreage and improve slope stability from the low marsh to the upland areas. Also, similar to Alternative 1, the southeastern tip of the trail would be removed and graded down to a low marsh elevations (3-4 feet NAVD88) and a boardwalk would be created across the low marsh areas and the newly created channel. A second trail would provide access to an overlook area with views of the marsh and creek. The bayberry colonies located in this area would remain intact and would not be excavated but remain a higher elevated "island". The boardwalk would extend around the creek side of the bayberry areas.

The areas within the eastern section would be graded down to elevations that could support a low marsh system (approximately 2 feet NAVD88) while the existing tidal systems along the northeastern side of the site would be maintained and the *Phragmites*-dominated areas would be graded down to elevations more supportive of *S. alterniflora* populations. The low marsh areas will slope at a one percent grade to the high marsh areas, which will be constructed at elevations of approximately 4 feet NAVD88. The high marsh area will be set on a 3:1 slope to reduce the area available for *Phragmites* re-invasion.

The restored marsh areas would be approximately 19 acres in size and would be planted with a mix of *S. alterniflora, S. patens, D. spicata*, and other native tidal marsh species. Newly created transition slopes would be stabilized with a salt-tolerant seed mixture and planted with small salt-tolerant shrubs.

As in Alternative 1, all excavated materials that can be reused on site will be placed within the upland areas located within the bounds of the nature trail. Approximately one foot of sand would be placed overtop the excavated materials. The inland areas would then be planted with a native coastal grassland community. This restored area would be approximately 16.5 acres in size. The elevation of the trail in this area will increase, along with the surrounding areas. Excavated materials that can not be reused on site will be disposed of in a permitted landfill.

The total acreage of marsh and channels would be approximately 28 acres in size under Alternative 2, with restored low marsh areas about 17.5 acres in size. Based on order of magnitude estimates prepared for the preliminary designs, the total excavation quantities for Alternative 2 were estimated to be approximately 157,950 cubic yards and total cost for construction to be approximately $16 million. The cost for construction is largely driven by the costs related to the off-site disposal of landfill material, as much of the area proposed to be excavated under Alternative 2 is currently composed of trash and debris and therefore could not be reused within the coastal grassland area.

6.1.3 Alternative 3

As with Alternatives 1 and 2, Alternative 3 is confined to the 46-acre portion of the site located southwest of the golf course. Existing high marsh within this area is approximately 2 acres while low marsh is approximately 6 acres.

The design objectives of Alternative 3 are similar to the previous alternative objectives. However, some additional design strategies were evaluated. For instance, Alternative 3 includes the creation of a high marsh complex that is irregularly flooded and does not drain at low tide (i.e., a salt panne). An area such as a salt panne provides increased habitat complexity and microniches. The salinity that builds up within a salt panne aids in excluding certain species, such as *Phragmites*, but permits other salt marsh species, such as *Salicornia*, to flourish, resulting in a greater biological diversity. The salt panne would be established at an elevation of approximately 2 feet

NAVD88, however would be physically separated from the low marsh areas by a small earthen berm (approximately one foot wide) developed to an elevation of 3 feet NAVD88.

Total restored marsh acreage for Alternative 3, including the salt panne acreage, would be approximately 19 acres.

The nature trail system proposed in the design of Alternative 3 prevents public access to certain areas within the marsh complex. The nature trail does not extend into the bayberry area located along Mill Creek, preventing easy access to the bayberry area and surrounding salt marsh. The nature trail will be set at elevations of approximately 7 – 8 feet. A boardwalk would allow the public to travel through a section of the western marsh and over the western tidal channel system and back to the path. A second trail will provide access to an overlook with views of the marsh and creeks.

The design for Alternative 3 also includes intermittent channels coming in from both Gerritsen Creek and Mill Creek similar to those proposed under Alternative 2, but due to the presence of the salt panne complex, the southeastern channel does not reach as far into the marsh. Total proposed channel length would be over 2,000 linear feet. The channels would have a bottom elevation of -1 feet and bottom width of 6 feet, and 3:1 slope to a top width of 18 feet.

As in the previous alternatives, all excavated materials that can be reused on site will be placed within the upland areas located within the bounds of the nature trail creating a coastal grassland area of approximately 16.5 acres in size. Approximately three feet of sand would be placed overtop the excavated materials. The inland areas would then be planted with a native coastal grassland community. The elevation of the trail in this area will increase, along with the surrounding areas. Excavated materials that can not be reused on site will be disposed of in a permitted landfill.

Under Alternative 3, total restored marsh, salt panne, and channel acreage would be approximately 19 acres in size. Based on order of magnitude estimates prepared for the preliminary designs, the total excavation quantities for Alternative 3 were estimated to be approximately 136,000 cubic yards and total cost for construction to be approximately $14 million. The cost for construction is largely driven by the costs related to the off-site disposal of landfill material, as much of the area proposed to be excavated under Alternative 3 is currently composed of trash and debris and therefore could not be reused within the coastal grassland area.

6.1.4 Alternative 4

Alternative 4 differs from the previous three alternatives in that, to avoid costly excavation of the waste material discovered in the original 46 acres, more land was added to the project site for restoration consideration. The total project site acreage was increased to approximately 67 acres and included the land southeast of the original 46 acres that lies adjacent to Mill Creek. With the addition of this land, the baseline totals for high marsh acreage were still 2 acres with an additional acre of bayberry, but low marsh acreage increased to 10 acres. Within the existing areas noted as low marsh there are a few patches of diverse high marsh vegetation as well. The remaining area is dominated by *Phragmites*, with patches of wooded areas along the edge of the site near the golf course.

The design objective of Alternative 4, similar to the other alternatives, included increasing the twice-daily tidal inundation across as much of the site to the extent practicable by converting the *Phragmites*-dominated areas that lie adjacent to the existing salt marsh fringes to a healthy tidal

ecosystem. The focus of the excavation is limited to these *Phragmites*-dominated areas, while avoiding the large landfilled area located in the north. Low marsh areas will be developed to elevations of approximately 2 feet NAVD 88, and slope on a one percent grade to high marsh areas set at elevations of approximately 4 feet NAVD88. The high marsh areas will be set on typical slopes of 3:1 to reduce the area available for *Phragmites* re-invasion.

The design would include the preservation of the sandy beaches located at the southeastern end of the site, for utilization by horseshoe crabs.

The design also includes the creation of four microniches throughout the site to further increase habitat diversity. Two salt pannes, one located in the western area amongst a high marsh and bayberry-dominated area and one located in the southeastern end, would function similarly to the existing salt panne. The existing salt panne, located in the southeastern end, is located within the low marsh and is positioned at a slightly lower elevation than the surrounding marsh area. In this position, tidal flows enter the site but do not drain as quickly as the other areas in the marsh. The newly created salt pannes will be set at an elevation of approximately 2 feet NAVD88, but be set apart from the surrounding low marsh area by a one-foot wide earthen berm set at an elevation of approximately 3 feet NAVD88.

Other microniches included in Alternative 4 are small open water areas at the end of two of the created channels. These areas will be designed at slightly lower elevations than the channels (-1.5 feet NAVD88) so that approximately –0.5 feet of water remains in the pools throughout the tidal cycle. The channels proposed in Alternative 4 will function primarily to bring tidal flows to all areas of the salt marsh, allowing for proper tidal inundation periods across the site. The channels would have a bottom elevation of -1 feet and bottom width of 6 feet, and 3:1 slope to a top width of 18 feet.

The nature trail system proposed in the design of Alternative 4 allows for a small boardwalk at the southern edge of the site. This trail/boardwalk would provide views of the restored marsh and new tidal creek. In addition, a trail would be established through the central portion of the site to an overlook, providing views of the large expanse of restored marsh along the southeastern end of the site. This new overlook would be set at an elevation of approximately 12 feet. The new trail would then converge with the existing trail that runs adjacent to the golf course area along the eastern edge.

The upland area located outside of the existing trail within this portion of the site, currently dominated by *Phragmites*, would be utilized for the disposal of the *Phragmites* root mat that would be excavated from other areas of the site. This 7.5-acre area, which would then be circumscribed by the new trail, would continue to function as a *Phragmites*-dominated area even after restoration. A grassy mow strip approximately eight feet wide will buffer the *Phragmites* area from the nature trail. Seasonal mowing will help to keep the *Phragmites* from encroaching on other areas of the park.

Sandy materials excavated during the restoration of the site would be placed within the upland areas located within the bounds of the existing nature trail, creating a coastal grassland area of approximately 15 acres in size. Prior to placing clean sand, the proposed grassland area will be treated with an herbicide to disrupt *Phragmites* growth in the area. Approximately three feet of sand will be placed overtop the existing surface and any non-sandy excavated material. The inland areas would then be seeded and planted with a native coastal grassland community. The elevation of the trail in this area will increase, along with the surrounding areas. Final elevations

of the trail will be determined at a later phase of the design, but the trail will be designed to include full views of the surrounding marsh areas.

Under Alternative 4, total restored marsh, salt panne, channels and open water acreage would be approximately 20.5 acres in size. Based on order of magnitude estimates prepared for the preliminary designs, the total excavation quantities for Alternative 4 were estimated to be approximately 85,000 cubic yards and total cost for construction to be approximately $1.6 million. Costs for Alternative 4 were estimated to be much lower than the other alternatives because no landfill material is to be excavated and therefore no material is assumed to require offsite disposal.

The initial analysis of Alternative 4 assumed that all on-site land outside of any areas consisting of waste material would be utilized for purposes of salt marsh restoration. However, to determine the most cost effective amount of acreage to be used for Alternative 4, five sub-alternatives were then developed (Alternatives 4A through 4E). These sub-alternatives, or "reaches," were developed by delineating the approximate boundaries of the five watershed reaches located within Alternative 4, along with the area devoted to the coastal grassland restoration area. Figure 21 presents the five reaches that were analyzed for purposes of determining a the best alternative.

Reach 1, known as Alternative 4A, consists of the area located in the northwest portion of the site along Gerritsen Creek, approximately 10.5 acres in size, and when combined with the existing wetland acreage, results in total restored and existing marsh of 19 acres.

Reach 2 is located immediately south of Reach 1 and lies at the confluence of Gerritsen and Mill Creeks. Alternative 4B includes the restoration of Reaches 1 and 2, with a total restored and existing marsh acreage of 23.2

Alternative 4C consists of the restoration of Reaches 1, 2 and 3 for a total restored and existing marsh acreage of 29.4 acres. Reach 3 is located northeast of Reach 2 and lies along Mill Creek.

Reach 4 extends southeast from Reach 3 to the end of the existing project area along Mill Creek. Alternative 4D encompasses Reaches 1 through 4, for total restored and existing marsh acreage of 33.5 acres.

Alternative 4E extends landward to include Reach 5, along with Reaches 1 through 4, for a total restored and existing marsh acreage of 41 acres. The remaining land within the project area is devoted to the coastal grassland restoration area.

6.1.5 Summary of Alternatives

Table 6 provides a summary of the four alternative plans, along with the estimates of excavation quantities, restored acreage, order of magnitude costs.

TABLE 6 – COMPARISON OF PRELIMINARY PLANS (BASED ON ORDER OF MAGNITUDE COSTS)

	Excavation Quantities	Restored Acreage	Estimated Construction-Only Costs (Order of Magnitude)
Alternative 1	145,800	17 marsh 18 grassland	$15,000,000
Alternative 2	157,950	17.5 marsh 16.5 grassland	16,000,000
Alternative 3	136,000	19 marsh 16.5 grassland	14,000,000
Alternative 4	85,000	20.5 marsh 15 grassland	1,600,000

A preliminary review of the initial four alternatives (1 – 4), based on the proposed amount of restored acreage and the related estimated construction costs (order of magnitude construction costs only), shows Alternative 4 to provide the most benefit at the least cost. To analyze the alternatives more fully, a full benefit review of the initial four alternatives (1 – 4) was performed using the Evaluation of Planned Wetlands assessment methodology. A full cost effectiveness analysis was conducted of the initial four alternatives (1 – 4). After the cost effectiveness analysis determined that the only cost effective analysis was Alternative 4, an marginal cost analysis of sub-alternatives 4A – 4 E was performed using the Incremental Cost Analysis. The results of these analyses are presented below.

6.2 Description of Benefits

To determine the benefits associated with the restoration efforts of each alternative, a wetland functional assessment methodology was employed, specifically the Evaluation of Planned Wetland (EPW) methodology. The goal in employing the EPW assessment was to evaluate and document the capacity of the existing wetland site and the proposed wetland restoration alternatives to perform specific wetland functions and values. As such, current vegetative communities, tidal patterns, and human use patterns at Gerritsen Creek were observed, documented, and incorporated into a functional assessment of the existing site and the proposed restoration alternatives using the EPW procedure. Subsequently, the assessment results were then used to provide baseline information to characterize existing wetland communities, as well as to assess the increase in functions and values, or benefits, provided by the four restoration design options.

In providing a methodology to assess and compare the functional attributes of existing and planned wetlands, the EPW addresses six major groups of wetland functions: shoreline bank erosion control, sediment stabilization, water quality, wildlife, fish, and uniqueness/heritage (Bartoldus et al., 1994), as presented in Table 7.

Shoreline Bank (SB) Erosion Control: The shoreline bank erosion control function provides a relative measure of the wetland's capacity to provide erosion control and dissipate erosive forces at the shoreline bank.

Sediment Stabilization (SS): The sediment stabilization function provides a measure of the wetland's capacity to stabilize and retain previously deposited sediments.

Water Quality (WQ): The water quality function provides a relative measure of the wetland's capacity to retain and process dissolved or particulate materials.

Wildlife (WL): The wildlife function provides a measure of the degree to which a wetland functions as habitat for wildlife as described by habitat complexity (i.e., wetland edge, vegetation structure).

Fish (tidal) (FT): The fish (tidal) function provides a relative measure of the degree to which a wetland habitat meets the limiting factors, food/cover, and water quality requirements of tidal fish species.

Uniqueness/Heritage (UH): The uniqueness/heritage function indicates the presence of characteristics that distinguish a wetland as unique, rare, or valuable.

TABLE 7 – EPW FUNCTIONAL CAPACITY INDEX CATEGORIES

FUNCTION	ABBREVIATION	DEFINITION
Shoreline Bank Stabilization	SB	Capacity to provide erosion control and to dissipate erosive forces at the shoreline bank
Sediment Stabilization	SS	Capacity to stabilize and retain previously deposited sediments
Water Quality	WQ	Capacity to retain and process dissolved or particulate materials to the benefit of downstream surface water quality
Wildlife	WL	Degree to which a wetland functions as habitat for wildlife as described by habitat complexity
Fish (tidal)	FT	Degree to which a wetland habitat meets the food/cover, reproductive, and water quality requirements for fish
Uniqueness/Heritage	UH	Presence of characteristics that distinguish a wetland as unique, rare, or valuable

Two additional functions, fish (non-tidal pond/lake - FP) and fish (stream/river - FS), are also utilized within an EPW analysis, but were not assessed at Gerritsen Creek due to the lack of non-tidal pond/lake and stream/river ecosystems within the project area.

For each of these functions, several contributing elements are then rated utilizing the prescribed rating guidelines. Each function comprises a number of elements for which a site or planned site receives a score. The element scores are integrated into a Functional Capacity Index (FCI), a value ranging from 0.0 to 1.0, with 1.0 representing the best possible condition for that function. The FCI is then multiplied by the area of wetland being evaluated to provide a functional capacity rating for the wetland. This area-corrected term is called a Functional Capacity Unit (FCU).

6.2.1 EPW Methodology

Field investigations were conducted in the spring and summer of 2002, and were conducted by field team members experienced in coastal salt marsh ecology, wetland delineations, wetland

function and value assessments, data collection, and Quality Assurance/Quality Control. Unless otherwise noted, field-sampling methodology followed that specified in the EPW manual.

Site characteristics, such as community structure, bank stability, vegetative diversity, sediment types, and habitat characteristics, utilized in the EPW analysis were documented with photographs presented in Appendix D. Assessments were based on the average condition of all the polygons of the Wetland Assessment Area (WAA), which is the estuarine system that exists on site. The estuarine system includes the salt marsh fringe along Gerritsen and Mill Creeks, and the *Phragmites*-dominated areas that experience some tidal influence. The assessment involved recording a value from 0.0 to 1.0 or assigning a "NA" (not applicable) to each element based on an assessment of characteristics that may or may not occur within each wetland community. Team members assessed each element individually, and then compared results. Any differences between field member's responses for element values were discussed until team members came to a consensus on the appropriate value.

After site investigations were completed and existing literature was reviewed, the EPW worksheets (Bartoldus et al., 1994) were used to estimate the FCIs for the existing site (i.e., the WAA). Evaluators determined which functions were appropriate for consideration at the Gerritsen Creek site (SB, SS, WQ, WL, FT and UH) and which were not (FS and FP). Scores were developed by two teams and responses compared to refine the accuracy of the resultant FCIs.

After the four preliminary restoration alternatives were developed and approved, a functional assessment using the EPW of the four restoration alternatives was conducted following the procedures developed for the site in its existing state.

Element values for the six functions in the WAA and the four alternatives were recorded on score sheets and transferred to FCI calculation worksheets. FCI and FCU calculations were performed using the equations presented in the EPW manual. The data utilized in the analysis of the five conditions (existing site, Alternative 1, Alternative 2, Alternative 3, and Alternative 4) are presented in Appendix D.

A summary of the analysis and the numerical results of the EPW functional assessment for the five conditions of the project site are presented below. The EPW scores for each condition provide a means to assess the relative contribution of the existing or designed features for each of the five conditions (existing and four alternatives). It also permits the prioritization of functions in selecting features of restoration designs.

For each of the comparisons (existing versus alternative), the alternatives were evaluated based on the presence of wildlife concessions or habitat design components, additional features that enhance the wildlife utilization of the site. These might include the intentional addition of woody vegetation in the wetland area, the creation of areas of finer or coarser soil texture, or the addition of wildlife attractors such as snags (standing dead trees), brush piles, and deadfall. Considerations raised in the EPW are then evaluated for inclusion in the design of the preliminary alternatives.

6.2.2 Baseline Conditions for EPW Analysis

As documented in Section 3, Gerritsen and Mill Creeks border the existing site. A fringe marsh is located adjacent to the creeks dominated primarily by *S. alterniflora*, with patches of *S. patens, D. spicata*, *Phragmites*, and other high marsh vegetation. The adjacent upland areas have been greatly altered by the placement of dredged and waste fill material. One of the upland areas is

located within the bounds of the nature trail and the other within the northeastern section of the site. Both of these areas are dominated by dense stands of *Phragmites* monocultures. The inner upland fill area also has numerous small groups of early successional trees, while the few trees located within the eastern section are more mature.

The urbanized lands that surround the site serve primarily residential uses. The site itself is utilized heavily for passive recreation along the trails. Gerritsen and Mill Creek are both used for recreation purposes for boating, water skiing, and fishing. The majority of the site is protected from wind and weather by its position in the landscape: behind White Island, with higher land elevations surrounding it, subject to the calm tidal fluctuations. However, erosive forces created by boat use in the creeks are evident in the southeastern portion of the site. Within this area, boats tend to speed up and slow down near the abandoned bridge in Mill Creek, creating larger wakes than if they were motoring at a steady speed.

The surface soils on the site are generally composed of a peat layer resting on a bed of coarse sand. In the area along the southeastern tip, these organic silt layers have been made unstable by boat wakes and are actively eroding, exposing sandy beach.

The wildlife community is typical for this type of upland/wetland complex. As previously stated, the JABERRT reports identify bird, fish, and other wildlife species observed using the site.

6.2.3 Analysis of the EPW Scores for Each Restoration Alternative

Based on these general site characteristics, the site in its existing state was scored using the EPW as described below. Tables 8 through 11 present the existing site EPW calculations in comparison with each proposed alternative.

Shoreline Bank Erosion Control: The SB section of the EPW considers the influence of a number of elements on the potential for erosion. These elements include shoreline structures and obstacles, physical influences (e.g. fetch, boat traffic) and properties of the vegetation on site. Due to the potential for erosion from boat traffic in the area and from moderate disturbance to sediments, current conditions for SB ranked 0.92. Alternative 1 does not address the issue of boat traffic, but the presence of large bayberry islands at the southern edge of the site protects much of the wetland in Alternatives 2 and 3. While Alternative 4 does not include a single large bayberry island, structures can be designed along the shoreline to reduce wave exposure or signage and enforcement measures used to slow down boat speeds. These design features resulted in relatively higher scores for Alternatives 2, 3, and 4 (score for Alt. 1 was 0.94, for Alts. 2, 3 and 4 was 1.0).

Sediment Stabilization: The SS score results from a combination of elements (disturbance-related, vegetation and slope stability), resulting in a measure of the capacity of the wetland to stabilize and retain sediments. Current conditions at Gerritsen Creek scored 0.75 out of 1.0 for SS, with the reduction due to the possibility for human disturbance of soils at the site and by the potential for grazing by waterfowl to damage plant communities in the area. As public land, Gerritsen Creek will always be vulnerable to a certain amount of human disturbance. However, specific landscape features, such as tidal channels, which are major components of all four alternatives (the score for each alternative was 1.0), can significantly reduce the potential for human disturbance of sediments by effectively preventing physical access to the marsh area, all while still preserving the visual and recreational resource value of the site. Waterfowl grazing does not seem to contribute significantly to sediment loss at this site, although, in newly planted wetlands, waterfowl can play an enormous role in the removal of plants and subsequent sediment loss. The final design and construction plans will include herbivory controls, excluding waterfowl

from the wetland area for at least one year following the completion of the project so that the vegetation can become well established.

Water Quality: The WQ function is a measure of the ability of a wetland to retain and process particulate or dissolved materials, benefiting downstream water quality. It incorporates elements that include hydrology, disturbance, bank conditions, substrate and vegetation. For the WQ function, Gerritsen Creek currently scores 0.88 out of 1.0 due to the potential for disturbance by humans or waterfowl. Improvements, such as tidal channels to prevent human access to sensitive areas and herbivory controls to deter waterfowl grazing, result in higher scores for all four alternatives (score for each alternative = 1.0) than the original condition. In addition, both the current conditions and the alternatives are subject to the presence of sandy substrate in many areas of the site. Future incorporation of more fine mineral soils or more organic soils would increase the WQ score.

Wildlife: Current conditions at Gerritsen Creek score only 0.36 out of 1.0 for the WL function, largely an assessment of habitat complexity, whereas all four alternatives (0.66, 0.73, 0.75, 0.75) increase this low quality rating. The current site and Alternatives 1 and 2 support three vegetative layers while the addition of salt pannes and open water areas increase the number of strata to four layers for Alternatives 3 and 4. All four alternatives favorably increase the number of cover types, increase the interspersion of the cover types, limit the dominance of undesirable species, and add additional layers of woody vegetation and marsh channels. The woody layer addition also serves to increase the score for the spatial pattern of shrubs. All four alternatives increase the interspersion of water and vegetation to a greater degree than the site exhibits now, increasing the irregularity of the upland/wetland edge. In addition, each of the alternatives includes increased wildlife attractors, such as snags and other nesting sites. Wetland/upland edges and wetland/open water edges are currently linear, minimizing the linear interface or edge areas available for wildlife. Very few small creeks penetrate the existing marsh area and no islands of upland or even woody marsh vegetation rise out of the *Spartina* flats. The simplistic structure and interspersion of different vegetation types (herbaceous, deciduous, and evergreen) on the site reduces habitat value for many different species that could use the area. Increasing diversity of vegetation and strata in and around the wetland areas will improve the habitat value of the wetlands at Gerritsen Creek. These issues will be further addressed as the restoration design plan is progressed.

Fish-Tidal: The FCI for fish in a tidal system judges the limiting factors to fish passage, the availability of food and cover and water quality. Current conditions rate a FT score of 0.63 out of 1.0 and all four alternatives (0.75, 0.75, 0.75, 0.75) improve that score to a small degree. Explanations for the relatively modest increase compared to existing conditions include the existing moderate disturbance levels and sandy substrate, as well as the absence of rooted vascular aquatic vegetation beds in the lower shore zone (both in the current state and in all four alternatives). Furthermore, there exists and will continue to exist, the potential for nutrient and contaminant runoff to the site through storm water outfall and contamination from local sources. The addition of tidal channels will increase the tidal interspersion, as well as reduce human disturbance by limiting physical access, and provide more suitable habitat. Furthermore, additional *Spartina* vegetation will provide new structure and cover for larval fish using the marsh. The added feature of open water ponds in Alternative 4 will further increase the available habitat for fish species.

Uniqueness/Heritage: The UH functional capacity index incorporates association with several descriptors, including endangered species, rarity, unique features, historical or archaeological significance, natural landmark, park or sanctuary status, and scientific research site. The existing Gerritsen Creek site earned a UH of 1.0, as did all four alternatives (1.0, 1.0, 1.0, 1.0). Several

New York State Threatened and Endangered Species, including the peregrine falcon (*Falco peregrinus*), northern harrier (*Circus cyaneus*) and common tern (*Sterna hirundo*), have been observed on the site in the past two years, as presented in the JABERRT reports. The UH score will not be adversely affected by any of the restoration plans, and will, in fact, increase the scientific and educational values of the area. Very few restoration sites sport pre-restoration data of the quality that JABERRT has collected; and very few coastal grasslands grace the public lands on the shores of Long Island. Gerritsen Creek in its restored state will be an unparalleled asset to the larger Jamaica Bay and New York community.

Based on the EPW assessment, the Gerritsen Creek site in its current condition scored at or above 0.75 for every function, except WL for which it scored 0.36 and FT for which it scored 0.63. Gerritsen Creek, in its current condition, scored highest (1.00) in the UH category, based on its recreational and scientific use by humans, as well as its healthy bird populations.

The following sections present a comparison of the site in its existing state with each of the proposed alternatives. All area units are presented as acres.

Existing Site in comparison with Alternative 1: Alternative 1 differs from the other two alternatives primarily in that it lacks a high marsh island supporting an existing bayberry colony. Table 8 depicts the EPW comparison between the existing site conditions and Alternative 1.

TABLE 8 – EPW COMPARISON OF EXISTING SITE AND ALTERNATIVE 1

		Existing Site			Alternative 1			Net Change		
Function	**Code**	**FCI**	**Area**	**FCUs**	**FCI**	**Area**	**FCUs**	**FCI**	**Area**	**FCUs**
Shoreline Bank Stabilization	SB	0.92	8	7.4	0.94	25.5	24.0	0.02	17.5	16.6
Sediment Stabilization	SS	0.75	8	6.0	1.00	25.5	25.5	0.25	17.5	19.5
Water Quality	WQ	0.88	8	7.0	1.00	25.5	25.5	0.12	17.5	18.5
Wildlife	WL	0.36	67	24.1	0.67	67	44.9	0.31	0	20.8
Fish – Tidal	FT	0.63	8	5.0	0.75	25.5	19.1	0.12	17.5	14.1
Uniqueness/Heritage	UH-	1.00	67	67.0	1.00	67	67.0	0	0	0
TOTAL FCUs for Alternative 1 (without UH)							**139.0**			

Alternative 1 offered little improvement to the SB function over existing conditions because of the absence of a large bayberry barrier island to protect the wetland from any potential wave action. The slight improvement in this score from existing conditions is due to anticipated reductions in human and waterfowl disturbances after restoration. Total FCUs, however, increased greatly due to the increase in size of the marshes.

Scores for the SS and WQ functions increased to 1.0 under Alternative 1. The values of the WQ and SS functions were enhanced due to the removal of some human and waterfowl disturbances to marsh areas. The FCUs were greatly increased by the increase in size of both the marsh and channel areas.

The Wildlife (WL) function score increased to 0.67 under Alternative 1, largely due to the interspersion and random patterning of different vegetative cover types (woody and emergent) in the wetland, and also to the inclusion of the preserved bayberry clumps as part of the wetland area instead of as discrete upland islands. The proposed channels that would meander through the marsh also contributed significantly to the increase in the WL score. The inclusion of specific wildlife attractors such as snags and dead wood boosted the WL score as well.

The Fish Tidal (FT) score only increased to 0.75 from the original score of 0.63 under this alternative, even with the inclusion of fish cover features in the design. This small increase in the FT score was due entirely to the anticipated prevention of human and waterfowl disturbance (i.e., devegetation by geese) to the majority of the marsh habitat after restoration.

Existing Site in comparison with Alternative 2: Alternative 2 included a large bayberry island and more habitat design components than Alternative 1. All other site features, although slightly different than those presented under Alternative 1, are viewed under the EPW process as very similar to the site features of Alternative 1. Table 9 depicts the EPW comparison between the existing site conditions and Alternative 2.

TABLE 9 – EPW COMPARISON OF EXISTING SITE AND ALTERNATIVE 2

		Existing Site			Alternative 2			Net Change		
Function	**Code**	**FCI**	**Area**	**FCUs**	**FCI**	**Area**	**FCUs**	**FCI**	**Area**	**FCUs**
Shoreline Bank Stabilization	SB	0.92	8	7.4	1.0	27	27.0	0.08	19	19.6
Sediment Stabilization	SS	0.75	8	6.0	1.0	27	27.0	0.25	19	21.0
Water Quality	WQ	0.88	8	7.0	1.0	27	27.0	0.12	19	20.0
Wildlife	WL	0.36	67	24.1	0.73	67	49.0	0.37	0	24.9
Fish – Tidal	FT	0.63	8	5.0	0.75	27	20.2	0.12	19	15.2
Uniqueness/Heritage	UH	1.00	67	67.0	1.00	67	67.0	0	0	0
TOTAL FCUs for Alternative 2 (without UH)							**150.2**			

This alternative, because of the presence of the large bayberry island, increased the SB score to 1.0, which is greater than Alternative 1. Similar to Alternative 1, SS and WQ scores increased to 1.0 due to the anticipated reduction of human and waterfowl impacts to a majority of the site and increased acreages. Alternative 2 increased the WL score to 0.73, due to the presence of the upland island and marsh channels, in addition to the wildlife features mentioned for Alternative 1. The FT score increased to 0.75, for the same reasons as in Alternative 1. Although the FCIs for Alternatives 1 and 2 are similar, the FCUs for Alternative 2 are higher due to the increased acreages for marsh and channel proposed for Alternative 2.

Existing Site in comparison with Alternative 3: Seen through the lens of EPW, Alternatives 2 and 3 are virtually identical; the only notable difference between the two reflected in the EPW analysis is the acreage of the marsh and channels under scrutiny. Table 10 depicts the EPW comparison between the existing site conditions and Alternative 3.

TABLE 10 – EPW COMPARISON OF EXISTING SITE AND ALTERNATIVE 3

		Existing Site			Alternative 3			Net Change		
Function	**Code**	**FCI**	**Area**	**FCUs**	**FCI**	**Area**	**FCUs**	**FCI**	**Area**	**FCUs**
Shoreline Bank Stabilization	SB	0.92	8	7.4	1.00	27	27.0	0.08	19	19.6
Sediment Stabilization	SS	0.75	8	6.0	1.00	27	27.0	0.25	19	21.0
Water Quality	WQ	0.88	8	7.0	1.00	27	27.0	0.12	19	20.0
Wildlife	WL	0.36	67	24.1	0.73	67	48.9	0.37	0	24.8
Fish – Tidal	FT	0.63	8	5.0	0.75	27	20.2	0.12	19	15.2
Uniqueness/Heritage	UH	1.00	67	67.0	1.00	67	46.0	0	0	0
TOTAL FCUs for Alternative 3 (without UH)							**150.1**			

Similar to Alternative 2, the presence of the large bayberry island in Alternative 3 increased the SB score to 1.0. The SS and WQ scores also increased to 1.0 due to the anticipated reduction of human and waterfowl impacts (e.g. herbivory by geese) across the majority of the marsh areas. Again, the presence of the upland islands and marsh channels increased the WL score to 0.73.

Existing Site in comparison with Alternative 4: Alternative 4 consists of similar design concepts as presented in Alternatives 1 through 3; however the site plan encompasses the southeastern section of the site along Mill Creek. This allows for a larger restoration area, including the creation of salt pannes and open water areas interspersed with the low marsh. Table 11 depicts the EPW comparison between the existing site conditions and Alternative 4.

Alternative 4 holds intact the existing bayberry islands helping to stabilize the shoreline. However, to ensure protection against the erosive forces that appear to exist in the southeastern section, additional design features will be added as the design of this alternative progresses. With these design features, the functional score for SB increased to 1.0, as did the scores for SS and WQ due to the anticipated reduction of human and waterfowl impacts (e.g. herbivory by geese) across the majority of the marsh areas. Again, the presence of the upland islands and marsh channels increased the WL score to 0.73.

TABLE 11 – EPW COMPARISON OF EXISTING SITE AND ALTERNATIVE 4

		Existing Site			Alternative 4			Net Change		
Function	**Code**	**FCI**	**Area**	**FCUs**	**FCI**	**Area**	**FCUs**	**FCI**	**Area**	**FCUs**
Shoreline Bank Stabilization	SB	0.92	12	11.0	1.00	32.5	32.5	0.08	20.5	21.5
Sediment Stabilization	SS	0.75	12	9.0	1.00	32.5	32.5	0.25	20.5	23.5
Water Quality	WQ	0.88	12	10.6	1.00	32.5	32.5	0.12	20.5	21.9
Wildlife	WL	0.36	67	24.1	0.73	67	48.9	0.37	0	24.8
Fish – Tidal	FT	0.63	12	7.6	0.75	32.5	24.4	0.12	20.5	16.8
Uniqueness/Heritage	UH	1.00	67	67.0	1.00	67	67.0	0	0	0
TOTAL FCUs for Alternative 4 (without UH)							**170.8**			

6.2.3 EPW Comparison Summary

The results of the EPW analysis shows that the most important features of the restoration design are the improvements in water quality, along with the protection from erosive forces, reduction of human and waterfowl (e.g. geese) disturbance, and the creation of channels, salt pannes and open ponds in the marsh plain to increase the habitat diversity and the area of interface between the wetland and open water. Because of the current use of the site for recreational and scientific purposes, the UH function is already at highest functional capacity in its current condition and does not vary from alternative to alternative. All four alternative designs increase the other five applicable wetland functions addressed in the EPW methodology. They differ in the FCI score only in the SB and WL functions, in which Alternative 1 scored slightly lower than Alternatives 2, 3, and 4.

When the FCI is applied to the wetland functional area to quantify the FCUs encompassed by each alternative, Alternative 4 scores higher than the other three alternatives due to the increase in restored wetland acreage.

Based on the EPW assessment, all four alternative restoration designs represent drastic improvements to the functions of the wetland attributes for SB, SS, WQ, WL, and FT. However, Alternative 4 has the greatest sum of functional capacity units, for a total of 170.8 FCUs, whereas Alternative 1 has 139 FCUs, Alternative 2 has 150.2 FCUs, and Alternative 3 has 150.1 FCUs.

6.3 Cost Analysis Methodology

The USACE ecosystem restoration policies require that restoration projects include a Cost Effectiveness and Incremental Cost Analysis (CE/ICA). The CE/ICA analyses are decision-

making tools that aid in evaluating incremental costs and outputs associated with various restoration plans so that the plan that produces the most ecological output in the most cost efficient manner is selected for implementation.

The CE analysis provides information on which restoration alternative provides the most ecological benefit (output) for the least amount of money. The ICA is then used to reveal and evaluate incremental changes in costs for increasing levels of ecological output (i.e., acres of habitat). Together, the CE/ICA are used to formulate alternative plans from combinations of possible restoration measures and evaluate plan benefits, or outputs.

6.3.1 Cost Effectiveness/Incremental Cost Analysis

The four alternatives developed for restoring tidal salt marsh and coastal grassland on the Gerritsen Creek site were analyzed using the CE/ICA methodology. In general, the alternatives vary in the amount of salt marsh to be restored, the amount of excavation to occur, and the location of new tidal channels. The fourth alternative, however, is slightly different in that it was designed to avoid areas known to contain waste material below the surface, and thus negating the requirement to dispose of landfill material offsite.

The results of the EPW analysis indicate that all four restoration design alternatives improve the overall wetland functionality of the site, although Alternative 4 represents the greatest overall functional improvement. The results of the EPW analysis are incorporated in this CE/ICA analysis.

The tasks required to conduct a NER analysis for the Gerritsen Creek study are described in terms of the six steps listed in the USACE ER 1105-2-100. In these steps, the CE and ICA are identified separately and begin after the outputs and costs have been determined. IWR-Plan software was used in performing these steps. The costs utilized in the CE/ICA analysis were based on order of magnitude costs of the construction, design and specifications, and monitoring and maintenance of the conceptual plans. As a result, the costs presented in this section are higher than the preliminary order of magnitude costs presented in Section 6.1.

Step 1 - Display outputs and costs: Calculate average annual outputs (not discounted) and equivalent annual costs (discounted) based on inputs over the 50-year planning horizon. The NER costs must include Operation and Maintenance (O&M) costs and Interest During Construction (IDC) costs. However, at this stage of planning for Gerritsen Creek site, the construction time schedules are not estimated so IDC is omitted from the analysis. Annualized costs are based on the FY 2002 federal discount rate of 6.125%.

Table 12 displays the values of cost and habitat unit parameters used in the CE analysis. The O&M costs include monitoring costs as well as maintenance of trails and boardwalks over the project life.

In general, costs for Alternative 4 are much less than those for Alternatives 1 through 3 because the construction of Alternative 4 would avoid lands that contain waste materials.

TABLE 12 – OUTPUTS AND COSTS

Alternative	First Cost ($1000)	Annual First Costs (6.125%) ($1000)	O&M ($1000)	Annual Total Cost ($1000)	Restored Marsh (Acres)
Existing	NA	NA	100	100	-
1	17,790	1,148	100	1,248	17.5
2	18,793	1,213	125	1,338	19.0
3	16,843	1,087	100	1,187	19.0
4	2,468	159	125	284	20.5

Step 2 - Identify combinable management measures: In this step, all possible combinations of management measures and scales are formulated. Because of the constraints associated with the project (limited project acreage and amount of restored marsh acreage necessary), none of the alternatives identified for Gerritsen Creek are combinable, all plans are mutually exclusive, and thus this step does not apply.

Step 3 - Calculate outputs and costs of combinations: All possible combinations of management measures and scales are sorted in terms of output. This provides the basis for developing a supply curve. As is often done, environmental outputs are measured in terms of acres. As indicated in Table 12 and discussed in the previous report sections, Alternative 4 provides the most restored marsh acreage (20.5 acres).

Step 4 - Conduct cost effectiveness analysis: A plan is cost effective if no other plan provides the same level of output for less cost and if no other plan provides more output for the same or less cost. This step identifies the best solution for a given amount (or range) of outputs. This essentially creates a supply curve and eliminates economically ineffective solutions.

Alternatives 1, 2, and 3 provide similar outputs at similar costs. Alternative 4 provides more marsh area than Alternatives 1, 2 and 3 and costs much less. In annual terms, Alternative 4 costs the equivalent of $284,000 per year, in comparison to Alternatives 1, 2 and 3 which average approximately $1,260,000 per year. As presented previously in the Preliminary Alternatives Restoration Report (USACE, 2002), Alternative 4 also provides greater increases in wetland functionality than the other alternatives.

As a result of this analysis, Alternatives 1, 2 and 3 are dropped from consideration due to the high costs (mainly associated with the off-site removal of the landfill material) and relatively low output. Therefore, the remainder of the cost analysis focuses only the optimization of Alternative 4.

Progression of Analysis - Optimization of Alternative 4

The initial analysis of Alternative 4 assumed that all on-site land outside of any areas consisting of waste material would be utilized for purposes of salt marsh restoration. However, to determine the most cost effective amount of acreage to be used for Alternative 4, five sub-alternatives were then developed (Alternatives 4A through 4E). These sub-alternatives, or "reaches," were developed by delineating the approximate boundaries of the five watershed reaches located within Alternative 4, along with the area devoted to the coastal grassland restoration area. Figure 21 presents the five reaches that were analyzed for purposes of determining a "best buy" alternative.

Reach 1, known as Alternative 4A, consists of the area located in the northwest portion of the site along Gerritsen Creek, approximately 10.5 acres in size, and when combined with the existing wetland acreage, results in total restored and existing marsh of 19 acres.

Reach 2 is located immediately south of Reach 1 and lies at the confluence of Gerritsen and Mill Creeks. Alternative 4B includes the restoration of Reaches 1 and 2, with a total restored and existing marsh acreage of 23.2

Alternative 4C consists of the restoration of Reaches 1, 2 and 3 for a total restored and existing marsh acreage of 29.4 acres. Reach 3 is located northeast of Reach 2 and lies along Mill Creek.

Reach 4 extends southeast from Reach 3 to the end of the existing project area along Mill Creek. Alternative 4D encompasses Reaches 1 through 4, for total restored and existing marsh acreage of 33.5 acres.

Alternative 4E extends landward to include Reach 5, along with Reaches 1 through 4, for a total restored and existing marsh acreage of 41 acres. The remaining land within the project area is devoted to the coastal grassland restoration area. Table 13 presents the estimated costs and total salt marsh acreage under each alternative.

Figure 22 shows six points, each associated with one of the cost-effective alternatives presented above (Existing Condition, Alternatives 4A through 4E).

TABLE 13 – COSTS AND OUTPUTS FOR ALTERNATIVES 4A THROUGH 4E

Alternative	First Cost ($1000)	Annual First Costs (6.125%) ($1000)	O&M ($1000)	Annual Total Cost ($1000)	Total Marsh Area (Acres)
Existing	NA	100	100	100	13.0
4A	851	851	120	175	19.0
4B	1,349	1,349	140	227	23.2
4C	1,794	1,794	150	266	29.4
4D	2,069	2,069	160	294	33.5
4E	12,823	12,823	180	1,008	41.0

As presented, the site in its existing state provides 13 acres of salt marsh for an annual cost of only $100,000 and is associated with the first point located in the lower left hand corner of the figure. A trend line connects the annual cost and the acres of wetland habitat after restoration for each of the alternatives. This line represents the supply curve for acres of wetland habitat. Alternatives 1, 2 and 3 would lie above the supply curve and thus are not cost effective and are not shown in Figure 22.

Step 5 - Incremental cost analysis: The ICA identifies the subset of cost effective plans that are superior financial investments, called "best buys". Best buys are the most efficient plans at producing the output variable (marsh acreage). They provide the greatest increase in the value of the output parameter variable for the least increase in the value of the cost parameter variable. The first best buy plan is the most efficient plan, producing output at the lowest incremental cost per unit. If a higher level of output is desired than that provided by the first best buy plan, the second best buy plan is the most efficient plan for producing additional output, and so on.

That is the same as identifying the plans with the lowest incremental cost per habitat unit, also known as a marginal cost analysis. This step considers the most cost effective plans by scale of output, beginning with the existing condition. It eliminates the plans that are smaller in scale than the first best buy plan. The existing condition is considered to be a best buy. The incremental costs and outputs are first measured against the existing condition to determine what is referred to as the first best buy.

Table 14 displays the incremental cost of all cost effective plans relative to the existing condition. The alternatives are also displayed in order of marsh area outputs provided. Alternative 4D, with an incremental cost of $9,400 per acre has the lowest incremental cost and is the first best buy plan beyond the existing condition.

TABLE 14 – FIRST ITERATION OF INCREMENTAL COST ANALYSIS

Alternative	First Cost ($1,000)	Annual Cost (6.125%) ($1000)	Incremental Cost (6.125%) ($1000)	Total Marsh Area (Acres)	Net Restored Marsh (Acres)	Incremental Restored Marsh (Acres)	Incremental Cost/Area ($1000)
Existing	-	100	-	13.0	-	-	-
4A	851	175	75	19.0	6	6	12.5
4B	1,349	227	127	23.2	10.2	4.2	12.5
4C	1,794	266	166	29.4	16.4	6.2	10.1
4D	2,069	294	194	33.5	20.5	4.1	9.4
4E	12,823	1,008	908	41.0	28.0	7.5	32.4

Step 6 - Recalculate incremental costs: This step uses iterative incremental cost analysis to identify plans where there is a significant change in incremental costs and identify the potential NER plans. The first step in this process looks at the incremental costs and outputs for plans larger than the first best buy plan. Plans larger (i.e. providing more output) than the last best buy plan are iteratively considered with the incremental costs and outputs relative to that last plan.

As is indicated in Table 14, the existing plan is considered in comparison to the five alternatives (4A – 4E). Alternative 4A provides 6 additional acres of restored marsh beyond that of the existing marsh for a total marsh acreage of 19 acres (existing 13 plus 6 incremental), at an incremental cost of $12,500 per acre for a total cost of $75,000. Alternative 4B provides 4.2 additional acres more than Alternative 4A, for a net restored area of 10.2 acres and a total marsh area of 23.2 acres. Alternative 4C provides 6.2 additional acres compared to Alternative 4B, with net restored marsh acres amounting to 16.4, and a total marsh area of 29.4 acres. Alternative 4C results a lower incremental cost than the previous alternatives at $10,100 per acre. However, alternative 4D results in the lowest overall incremental cost, at $9,400 per acre, and is therefore seen as the best buy plan. Alternative 4E results in the greatest restoration output, with a net of 28 restored acres for a total marsh acreage of 41. However, Alternative 4E also results in the highest incremental cost of $32,400 per acre for a total cost of $908,000.

Alternatives 4A, 4B and 4C are not preferred since they provide less output at a greater cost, as is the site in its current state since it provides no additional output.

Because Alternative 4E yields the highest output, it is then iteratively considered with the incremental costs and outputs relative to Alternative 4D, the last best buy plan. These results are presented in Table 15.

Table 15 compares only Alternatives 4D (the best buy plan) and 4E (the plan with the greatest output) as the basis for comparing incremental values associated with the remaining cost effective plans. In other words, Alternative 4D is used as the baseline in Table 15, in contrast to Table 14 where the existing conditions was used as the baseline.

TABLE 15 – SECOND ITERATION OF INCREMENTAL COST ANALYSIS

Alternative	First Cost ($1000)	Annual Cost (6.125%) ($1000)	Incremental Annual Cost ($1000)	Total Marsh Area (Acres)	Incremental Marsh Area (Acres)	Incremental Annual Cost/Area ($1000)
4D	2,069	294	-	33.5	-	-
4E	12,823	1,008	717	41.0	7.5	$95.6

As indicated in Table 15, Alternative 4E is the only remaining plan. The iterative process of identifying best buy plans is concluded as the incremental cost per acre for Alternative 4E is determined to be $95,600 relative to Alternative 4D.

Table 16 displays a summary of the incremental cost analysis for the best buy plans.

The analysis identifies three best buy plans for decision makers to consider. The existing site has only 13 acres of marsh and costs $100,000 annually to maintain. Alternative 4D costs $2 million to develop an additional 20.5 acres of marsh, with O&M costs increasing by $60,000. The incremental annual cost per acre of developing this marsh is estimated to be almost $10,000.

The last best buy plan (Alternative 4E) provides an additional 7.5 acres of marsh over Alternative 4D at an additional cost of about $10 million beyond the area and cost associated with Alternative 4D. The annual cost per additional area of developing this marsh is estimated to be about $100,000.

TABLE 16 – INCREMENTAL COST ANALYSIS SUMMARY ($1000)

	Annual Cost ($1000)		Marsh Area		Incremental Cost/Area ($1000)
Alternative	Total	Incremental	Total	Incremental	
Existing	100	-	13.0	-	-
4D	294	194	33.5	20.5	9.4
4E	1,008	717	41.0	7.5	95.6

6.3.2 Summary of Cost Analysis

Based on the CE/ICA cost analysis presented above, it is concluded that Alternative 4D is the "best buy" alternative for restoring the marsh at Gerritsen Creek. In other words, Alternative 4D provides the greatest output (marsh area) at the lowest cost.

6.4 National Ecosystem Restoration Plan

Based on the results of the alternatives analysis, the New York District of the USACE will select a NER plan based on the following criteria:

- Improvement in quantity and/or quality of desired ecosystem resources as measured by the EPW;
- Results of cost-effectiveness and incremental cost analyses;
- Significance of ecosystem outputs produced by the project in terms of institutional, public, and technical recognition;
- Acceptability, completeness, effectiveness, and efficiency of the plan; and,
- Risk and uncertainty associated with the costs and outputs of the alternative restoration plans.

The selected NER plan will be the ecosystem restoration plan of the desired scale that maximizes the monetary and non-monetary beneficial effects/outputs as compared to the monetary and non-monetary costs.

According to the *Planning Guidance Notebook* ER 1105-2-100, the types of improvements recommended for USACE involvement in ecosystem restoration include improving degraded ecosystem structure and function. Of particular interest to the USACE are restoration projects involving wetlands, floodplains, and aquatic systems. USACE restoration policy focuses on engineering and water control solutions rather than land acquisition. Possible improvements recommended by USACE policy include, but are not limited to: restoring tidal creeks and tidal pond habitat; restoring tidal hydrology and native wetland vegetation; using dredged material to restore wetlands; and, restoring conditions conducive to native species establishment (USACE, 2000).

6.5 Recommended Plan

Based on the analysis presented above, Alternative 4D was chosen as the recommended ecosystem restoration design alternative to progress to the design plans (presented in Appendix D). This alternative provided the greatest restoration benefits at the lowest cost.

The design objective of the recommended plan is to increase the twice-daily tidal inundation across as much of the site to the extent practicable by converting the *Phragmites*-dominated areas that lie adjacent to the existing salt marsh fringes to a healthy tidal ecosystem. The focus of the excavation is limited to these *Phragmites*-dominated areas, while avoiding the large landfilled area located in the north. Low marsh areas will be developed to elevations of approximately 2 feet NAVD 88, and slope on a one percent grade to high marsh areas set at elevations of approximately 4 feet NAVD88. The high marsh areas will be set on slopes of 3:1 to reduce the area available for *Phragmites* re-invasion.

Prior to any construction on site, the project site area currently dominated by *Phragmites* will be sprayed with an herbicide. The herbicide will be applied, in accordance with all federal, state and local regulations, in the late summer/early fall to the *Phragmites*. After approximately 45 – 60 days, the *Phragmites* areas will be mowed. The wrack will not be removed at this time, but will be removed during excavation of the site.

The excavation of the marsh areas will be performed using long-reach excavators during periods of low tide. Excavated material will be separated, and all sandy material will be disposed of within the area designated to become coastal grassland, while non-sand material (*Phragmites* wrack and root mat, clay and silt materials) will be disposed of in the 7-acre area designated for *Phragmites* disposal. Due to the stratified nature of the material that currently exists on site, no screening will be necessary to separate the *Phragmites* root mat from the sandy material.

Immediately following excavation of the marsh areas, the low marsh and high marsh areas will be planted on 18- to 24-inch centers with *Spartina alterniflora* plugs and a tri-plug of *Spartina patens*, *Distichlis spicata*, and *Juncus gerardii*, respectively. Plugs will be planted from mid-April until late June. Marsh areas will be fenced to minimize herbivory pressure on the newly planted vegetation. The herbivory fencing will remain for the first two growing seasons.

The design of the recommended plan includes the preservation of the sandy beaches located at the southeastern end of the site, for utilization by horseshoe crabs. No plants will be placed within this area. Erosive forces from either boat wakes or refraction from the historical pier may have created these sandy beaches. Therefore, as the design for the recommended plan is progressed, preventive measures to prevent future erosion may be incorporated.

The design also includes the creation of four microniches throughout the site to further increase habitat diversity. Two salt pannes, one located in the western area amongst a high marsh and bayberry-dominated area and one located in the southeastern end, would function similarly to the existing salt panne. The existing salt panne, located in the southeastern end, is located within the low marsh and is positioned at a slightly lower elevation than the surrounding marsh area. In this position, tidal flows enter the site but do not drain as quickly as the other areas in the marsh. The newly created salt pannes will be set at an elevation of approximately 1.5 feet NAVD88, but be set apart from the surrounding low marsh area by a one-foot wide earthen berm set at an elevation of approximately 3 feet NAVD88. The salt pannes will be planted with a mix of high and low marsh species to increase diversity.

Other microniches included in the recommended plan are small open water areas at the end of two of the created channels. These areas will be designed at slightly lower elevations than the channels (-1.5 feet NAVD88) so that approximately -0.5 feet of water remains in the pools throughout the tidal cycle. These open water areas will be over-excavated to allow for some sedimentation prior to the establishment of the plant material in the surrounding areas. The pools will not be planted.

The sinuous intermittent channels proposed in the recommended plan will function primarily to bring tidal flows to all areas of the salt marsh, allowing for proper tidal inundation periods across the marsh. The channels will have a bottom elevation of -1 feet and bottom width of 6 feet, and 3:1 slope to a top width of 18 feet.

The existing trail will be relocated landward to increase marsh area and to stabilize slopes from the marsh area to the trail. Along the southern edge of the site, at the confluence of Gerritsen and Mill Creeks, the nature trail will include a small boardwalk that traverses the low marsh and one of the tidal channels. This trail/boardwalk will provide views of the restored marsh and new tidal creek. The boardwalk will be similar in design to the boardwalk that currently exists on site near the Nature Center.

Additional trail will be established through the central portion of the site to an overlook, parallel to the salt marsh along Mill Creek, providing views of the large expanse of restored marsh along the southeastern end of the site. The trail will be at an elevation of approximately 10 feet while the new overlook will be set at an elevation of approximately 12 feet. The new trail will converge with the existing trail that runs adjacent to the golf course area along the eastern edge of the project site.

The upland area located outside of the existing trail within this portion of the site, currently dominated by *Phragmites*, would be utilized for the disposal of the *Phragmites* root mat and other

non-sandy material to be excavated from other areas of the site. This 7.5-acre area, which will be circumscribed by the new trail, will be mowed as part of the overall site maintenance plan, but will not be planted or seeded following construction.

Sandy materials excavated during the restoration of the site would be placed within the upland areas located within the bounds of the existing nature trail, creating a coastal grassland area of approximately 15 acres in size. A minimum of three feet of sand will be placed overtop the existing land and any non-sandy excavated materials. Microtopography will be created after placement of the sands.

The coastal grassland area will then be seeded and planted with a native coastal grassland community. The interior of this area will be seeded with a mix of coastal grasses (at a rate of 50 pure live seed per square foot), while the exterior fringe will include plugs of coastal grasses and herbaceous species. Annual grasses also will be seeded to stabilize the soil surface over the first year of growth.

A fence will be placed on both sides of the trail to control access to newly seeded and planted areas. The top height of the fence will be slightly below the average height of the grass species planted and seeded on site to discourage predatory birds from using the fence as a roost. The fences will be placed to heights consistent with the maximum plant growth and will be designed in similar fashion to the existing boardwalk located near the Nature Center.

Costs based on 30 percent design for the recommended plan are included in Appendix L and detailed in Section 6.6.

6.6 Micro-Computer Aided Cost Estimating System for Recommended Plan

A Micro-Computer Aided Cost Estimating System (MCACES) Cost Estimate was developed for the preferred alternative based on the 30-percent Design Drawings for the "Tidal Marsh Community Restoration Design for Gerritsen Creek". As a result, the costs presented at this stage are more refined than the costs presented in the previous sections as preliminary and conceptual order of magnitude costs.

Based on the 30-percent Design Drawings, a preliminary construction schedule was prepared to aid in the development of the cost estimate. Total project duration is estimated at approximately eight months, with excavation, grading, and site improvements estimated at approximately six months and planting estimated at approximately two months. Depending on the actual start of excavation and grading, there may be a lag in the schedule between the end of the first six-month period and the beginning of the two-month planting period to properly correspond with the appropriate spring planting season, although plans are for planting to follow construction immediately to prevent potential erosion.

The MCACES Cost Estimate was developed using unit prices for the New York Metropolitan area. Unit prices were developed based on general knowledge of the construction market and in certain instances with the assistance of the *R.S. Means Heavy Construction Cost Data 16th Annual Edition: 2002* (Chandler et al, 2001). The unit prices include all contractor overhead and profit and reflect labor and material pricing in the New York Metropolitan area. The following percentages were used: bond – one percent; escalation – three percent; and design contingence – 15 percent.

The following items of work were developed based on the 30-percent Design Drawings and the anticipated scope of work to construct the tidal wetland restoration and amenities:

Item 1 – Mobilization

Mobilization of the site includes the establishment of the support facilities within the construction staging area, as well as the mobilization of the support facilities (i.e., office trailers, storage trailers, small tools, etc.) and heavy equipment for construction operations. The work required to remove the support facilities from the construction staging area is also included under this item as well as the demobilization of the heavy equipment and all support facilities. Monthly operating costs for the support facilities are included under the item "General Conditions."

Labor for the mobilization includes: a crew of one foreman, four general laborers, one operator, and one teamster. Equipment for mobilization includes: one rubber tire loader, one lowboy trailer and miscellaneous support vehicles (i.e., pick-ups, mason dump). Major materials include: temporary fence.

The work of this item includes:

a. Setting up and mobilization costs for two office trailers at the site – one for the USACE and one for the contractor;
b. Connecting electric power and telephone service to the trailers;
c. Mobilizing storage trailers/containers, heavy construction equipment, and miscellaneous equipment;
d. Erecting temporary fencing at the staging area for security; and
e. Developing and erecting project sign and informational signs.

Item 2 – Temporary Haul Road

The temporary haul road work item includes the work of constructing the site access road and the gravel base for the construction staging area. After stripping and stockpiling the topsoil from the proposed access road and staging area, a geotextile will be placed to provide structural support for the roadway, to facilitate the removal of the gravel at the completion of the project, and the subsequent restoration of the areas with the stripped topsoil. Stockpiled topsoil will be stabilized with temporary seeding during the construction period per soil erosion and sediment control requirements.

Labor for the temporary haul road includes a crew of one foreman, four general laborers, two operators, and one teamster. Equipment for the temporary haul road includes: one D5 size bulldozer, one rubber tire loader, one off-road dump, and miscellaneous support vehicles (i.e., pick-ups, mason dump). Major materials include geotextile fabric and gravel.

The work of this item includes:

a. Clearing site access road from East 38th Street to the staging area;
b. Furnishing and installing geotextile under site access road and temporary parking/staging area;
c. Furnishing and installing gravel for site access road and parking/staging area;
d. Extending haul road into site for delivery of clean sand cover material; and
e. Restoring the access road, haul road, staging and parking areas.

Item 3 – Soil Erosion and Sediment Control

Soil erosion and sediment control devices will be established at the commencement of site operations and maintained throughout the construction period. Devices will be installed per the approved soil erosion and sediment control plans and maintained accordingly.

Labor for the soil erosion and sediment control includes a crew of one foreman, two general laborers, one operator, and one teamster. Equipment for the soil erosion and sediment control includes: one D3 size bulldozer, one rubber tire loader, and miscellaneous support vehicles (i.e., pick-ups, mason dump). Major materials include: silt fence, turbidity barriers, straw hay bales, gravel, seed, and straw mulch.

The work of this item includes:

a. Furnishing and installing approximately 7,500 linear feet of silt fence along the down slope side of areas to be filled;
b. Furnishing and installing approximately 3,000 linear feet of silt fence along the landward edge of the existing salt marsh to remain undisturbed by excavation of the proposed salt marsh;
c. Furnishing and installing turbidity barriers at the end of the proposed channels during excavation activities;
d. Furnishing and installing temporary hay bale dikes along slopes as required during filling and grading operations at grassland area;
e. Furnishing, installing and maintaining the truck tracking pad at the entrance to the site access road;
f. Furnishing temporary seeding and mulching as required; and
g. Creating and maintaining temporary sediment basin for fill area.

Item 4 – Clearing Site

Clearing the site will involve the application of an herbicide to help in the eradication of the existing stands of *Phragmites*. The herbicide will be applied from the ground using spray equipment mounted on all terrain vehicles. After the herbicide has been applied and allowed to penetrate into the root zone, the existing stands of *Phragmites* will be mowed. After mowing, the wrack and root mat will be stripped immediately prior to excavation and grading operations, within an area, and deposited in the disposal area. Clearing the site will also include the felling, chipping, and stump removal of several small existing tree stands that are within the excavation and grading zones, and the removal and storage of park amenities that would be impacted by excavation and grading operations.

Labor for clearing the site includes a crew of one foreman, four general laborers, two operators, and two teamsters. Equipment for clearing the site includes: one all-terrain vehicle (ATV) w/spray equipment, one ATV with a mower, one two-cubic yard (CY) hydraulic excavator, one D5 size bulldozer, two off-road dumps, and miscellaneous support vehicles (i.e., pick-ups, mason dump). Major materials will include herbicide.

The work of this item includes:

a. Spraying herbicide over approximately 40 acres of the site;
b. Mowing all existing *Phragmites* stands;
c. Stripping *Phragmites* wrack and placing in the disposal area;

d. Tree removals, and
e. Removing and storing park amenities (benches and signs) from the area.

Item 5 – Salt Marsh Excavation

Excavation for the proposed salt marsh restoration will involve the removal of sand and soil to the proposed grades of the salt marsh and associated channels and open water features. Based on the 30-percent Design Drawings, the total salt marsh and tidal channel excavation quantities are estimated to be approximately 103,500 CY (slightly higher than the preliminary quantities due to the more refined design and the addition of the tidal channels excavation).

Labor for the salt marsh excavation includes a crew of one foreman, five general laborers, two operators, and three teamsters. Equipment for salt marsh excavation includes: two two-CY hydraulic excavators, one D5 size bulldozer, two 20-CY off-road dumps, and miscellaneous support vehicles (i.e., pick-ups, mason dump). There are no major materials associated with this task.

The work of this item includes:

a. Excavating all proposed salt marsh areas to grade;
b. Excavating all proposed tidal channels and salt pannes; and
c. Hauling all excavated materials to the grassland or *Phragmites* disposal areas.

Item 6 – Placing Salt Marsh Excavation Material

Material excavated from the salt marsh restoration areas will be placed in the proposed grassland area and as cover over the *Phragmites* disposal area. As materials are excavated, the clean sand will be segregated for placement in the final lifts of the grassland areas to maximize the depth of clean sand in the top-most layers to optimize planting medium for the proposed grassland. Segregation may include temporary stockpiling within the grassland area to allow the less desirable excavated materials to be placed first.

Labor for salt marsh placement includes a crew of two general laborers and one operator. Equipment for clearing site includes one D6 size bulldozer and miscellaneous support vehicles (i.e. pick-ups, mason dump). There are no major materials associated with this task.

The work of this item includes:

a. Spreading and grading of salt marsh excavation within the grassland and *Phragmites* disposal areas.

Item 7 – Clean Sand Fill

To complete the planting medium for the grassland, enough sand to cover 0.5 feet over the grassland area will be imported and incorporated with on-site sand to develop a minimum 3-foot sand cover over the grassland area. The cost of trucking the material to the site is included in the unit price of the material and therefore no labor and equipment is included for the trucking operation.

Labor for clean sand fill placement includes a crew of two general laborers and one operator. Equipment for clean sand fill placement includes one D6 size bulldozer and miscellaneous support vehicles (i.e., pick-ups, mason dump). Major materials include clean sand.

The work of this item includes:

a. Importing from offsite, clean sand to be placed within the top 3 feet of the grassland area; and
b. Spreading and grading the clean sand over the grassland area.

Item 8 – Boardwalk

At the eastern end of the site, a boardwalk will be constructed to provide access over the salt marsh and tidal channel. The intent is to construct a boardwalk that is similar in appearance and materials to the existing metal boardwalk near the Nature Center at the entrance to the site.

Labor for the boardwalk construction includes a crew of one dock builder foreman, three dock builders, and two operators. Equipment for the boardwalk construction includes one pile driver and miscellaneous support vehicles (i.e. pick-ups, mason dump). Major materials include piles, structural steel, steel deck, and steel railings.

The work of this item includes:

a. Furnishing and installing all piles, foundations and substructure required for installation of the boardwalk; and
b. Furnishing and installing a pedestrian boardwalk, including railings, at the locations indicated on the plan. The boardwalk shall match in appearance and materials, the existing boardwalk at the entrance of the site.

Item 9 – Pedestrian Bridges

Where the boardwalk crosses the tidal channel in the salt marsh restoration area, two bridges will be utilized. The pedestrian bridges will be of similar construction as the boardwalk to match the existing metal boardwalk near the Nature Center in appearance and materials.

Labor for the pedestrian bridge construction includes a crew of one dock builder foreman, three dock builders, and two operators. Equipment for the boardwalk construction includes one crane and miscellaneous support vehicles (i.e., pick-ups, mason dump). Major materials include two pre-fabricated pedestrian bridges.

The work of this item includes:

a. Furnishing and installing all piles, foundations and substructure required for installation of the pedestrian bridges; and
b. Furnishing and installing two pre-fabricated pedestrian bridges of approximately 45 feet in length to bridge over the proposed channels. The pedestrian bridges shall match in appearance and materials, the existing boardwalk at the entrance of the site and the boardwalk furnished in Item 8 – Boardwalk.

Item 10 – Walking Trail

Due to the excavation for the proposed salt marsh and the grading and placement of excavated materials, the existing walking trails will require reconstruction as indicated on the 30-percent Design Drawings. The reconstructed walking trails will be of similar design and materials as the existing trails.

Labor for the walking trail construction includes a crew of one foreman, six general laborers, and two operators. Equipment for walking trail construction includes: one ½-CY hydraulic excavator, one D3 size bulldozer, one vibratory soil compactor, and miscellaneous support vehicles (i.e., pick-ups, mason dump). Major materials include gravel base course, gravel surface course, and edging material.

The work of this item includes:

a. Furnishing and installing all materials including gravel base course, gravel surface course, and edging material for the relocated walking trail as indicated on the 30-percent Design Drawings.

Item 11 – Restoration of Walking Trail

Due to the excavation for the proposed salt marsh and the grading and placement of excavated materials, portions of the existing walking trails will be impacted and will require restoration. The restored walking trails will be of similar design and materials as the existing trails.

Labor for the walking trail construction includes a crew of one foreman, six general laborers and two operators. Equipment for the walking trail construction includes: one ½-CY hydraulic excavator, one D3 size bulldozer, one vibratory soil compactor, and miscellaneous support vehicles (i.e., pick-ups, mason dump). Major materials include gravel base course, gravel surface course, and edging material.

The work of this item includes:

a. Furnishing and installing all materials including gravel surface course and edging material as necessary to restore sections of the existing walking trail, to remain, damaged during grading and hauling operations.

Item 12 – Wetland Plantings

Wetland plantings include both high and low marsh grasses and shrubs planted at the densities and locations as indicated on the planting plan. Wetland plants will be nursery grown and will include *S. alterniflora* plugs and tri-plugs of *S. patens, D. spicata* and *J. geraardi* planted on 18- to 24-inch centers. Salt marsh elder (*Iva frutescens*), groundsel tree (*Baccharis halimifolia*) will be planted on 5- to 10-foot centers.

Labor for wetland plantings includes a crew of one foreman, ten general laborers, and one operator. Equipment for wetland plantings includes one marsh master and miscellaneous support vehicles (i.e., ATVs, pick-ups, mason dump). Major materials include plant materials and fertilizer.

The work of this item includes:

a. Furnishing and installing all wetland plantings at the required locations and of the plant type as detailed on the Planting Plans, including all fertilizer and planting materials.

Item 13 – Grassland Plantings

Grassland plantings will include planting herbaceous plants and grasses around the perimeter of the grassland area.

Labor for grassland plantings includes a crew of one foreman, ten general laborers, and one operator. Equipment for the grassland plantings includes one ATV and miscellaneous support vehicles (i.e., pick-ups, mason dump). Major materials include plant materials.

The work of this item includes:

a. Furnishing and installing all grassland plantings at the required locations and of the plant type as detailed on the Planting Plans.

Item 14 – Transition Zone Plantings

Transition zone plantings will involve the planting of salt marsh elder (*Iva frutescens*) and groundsel tree (*Baccharis halimifolia*) in containers planted on 5- to 10-foot centers within the transition slopes from marsh to upland.

Labor for transition zone planting includes a crew of one foreman, ten general laborers, and one operator. Equipment for wetland seeding includes one marsh master and miscellaneous support vehicles (i.e., ATVs, pick-ups, mason dump). Major materials include plant materials and fertilizer.

The work of this item includes:

a. Furnishing and installing wetland seed mixture at the required locations and of the seed type as detailed on the Planting Plans, including all fertilizer and planting materials.

Item 15 – Seeding, Type Grassland Seed Mixture

Grassland seeding will involve the broadcasting of a native coastal grassland seed mixture and incorporation of the seed mixture into the planting medium of the grassland area at the locations and densities as detailed on the planting plans. The interior of this area will be seeded with a mix of coastal grasses (at a rate of 50 pure live seed per square foot), while the exterior fringe will include plugs of coastal grasses and herbaceous species. Annual grasses also will be seeded to stabilize the soil surface over the first year of growth.

Labor for the grassland seeding includes a crew of one foreman, ten general laborers, and one operator. Equipment for the grassland seeding includes one ATV and miscellaneous support vehicles (i.e., pick-ups, mason dump). Major materials include seed materials.

The work of this item includes:

a. Furnishing and installing grassland seed mixture at the required locations and of the seed type as detailed on the Planting Plans.

Item 16 – Herbivory Fencing

Herbivory Fencing includes the installation of four-foot high deer type fencing in the salt marsh areas to be planted, prior to planting. The fencing will be placed to create maximum 50 foot by 50-foot cells and erected on wood posts at 10 foot spacing.

Labor for herbivory fencing includes a crew of one foreman, five general laborers, and one teamster. Equipment for herbivory fencing includes miscellaneous support vehicles (i.e., ATV's, pick-ups, mason dump). Major materials include fence material, wood posts, mylar flagging, and cotton fiber string.

The work of this item includes:

a. Furnishing and installing herbivory fencing along the perimeter of all areas of salt marsh to be planted so that the fencing creates a four foot high barrier and cells that are approximately 50 foot by 50 foot in size.

Item 17 – Grassland Perimeter Control Fence

To control access to the grassland area, a perimeter control fence will be installed surrounding the grassland area. Three gates will be located along the fence to permit access for maintenance and emergency fire services. The top height of the fence should be at or slightly below the average height of the grass species planted and seeded on site to discourage predatory birds from using the fence as a roost. The bottom of the fence should be open to allow unobstructed access by small mammals and reptiles. Fence materials will be fire resistant (i.e., metal) and, in general, will visually complement the materials utilized in the construction of the boardwalks.

Labor for the construction of the perimeter control fence includes a crew of one foreman, five general laborers, one operator, and one teamster. Equipment for the fence construction includes one farm tractor w/post hole attachment and miscellaneous support vehicles (i.e., pick-ups, mason dump). Major materials include steel line and pull posts, aluminum or steel fence fabric, and concrete for post support.

The work of this item includes:

a. Furnishing and installing perimeter control fence including posts, concrete, top wire, and fence fabric. Work also includes the furnishing and installation of one 12-foot wide, double-leaf gate for vehicle access and two 6-foot wide single leaf gates.

Item 18 – Maintenance of Traffic

During the hauling of materials to the site, the contractor will provide traffic control devices and traffic control officers (flagmen) at the point of access to the site and as necessary at adjacent intersections.

Labor for the maintenance of traffic includes one flagman. Equipment for the maintenance of traffic includes miscellaneous support vehicles (i.e., pick-ups, mason dump). Major materials include construction signs and traffic control devices (cones, barrels, barricades).

The work of this item includes:

a. Furnish traffic control devices and traffic control officers during all hauling operations to protect vehicular and pedestrian traffic at the entrance to the site access road and along the roadways, streets and intersections immediately adjacent to the site (intersection of Avenue U and East 38th Street).

Item 19 – General Conditions

The item of General Conditions covers the cost of providing monthly support services at the construction site including construction layout for the setting of lines and grades for the salt marsh restoration.

Labor for general conditions will be generally covered as incidental to the other items of work but will include a laborer for general cleanup and a teamster to act as a driver for the picking up of miscellaneous materials. Labor for the construction layout includes a crew of one chief of party, one instrument operator, and one-rod person. Equipment for the construction layout includes: total station, levels, rods, prisms, etc., including support vehicles. Major materials include construction stakes.
The work of this item includes:

a. Monthly operating costs including trailer rental costs, sanitary facility costs, electric and telephone costs, miscellaneous tool rental costs and miscellaneous materials costs;
b. Furnish construction lines and grades by qualified surveyors under the direction of a State of New York Licensed Surveyor, to properly layout and construct the work of this project;
c. Furnish all personnel, survey equipment, stakes, calculations, and any and all other items of work necessary to provide the required lines and grades for construction; and
d. Provide an "As-Built" set of contract drawings, indicating with red lines, any and all changes to the original design.

PART 7 – ENVIRONMENTAL ANALYSIS OF PROPOSED ACTION

The environmental effects of the recommended plan on the physical, ecological, cultural, aesthetic, socioeconomic, and recreational conditions of the existing site are presented in the following sections.

7.1 Land Use and Zoning

Implementation of the recommended plan will result in a change of land cover types primarily from a *Phragmites*-dominated upland to a tidal marsh ecosystem. The increased marsh area will continue to provide open space use of the land, and will provide additional recreational and aesthetic uses of the land due to the additional trail, access to the water's edge, and better viewsheds of the open spaces. No adverse effects to land use are anticipated from the implementation of the recommended plan.

The project area is located within a designated park area, and thus is not zoned. The site will continue to function as parkland, thus no adverse effects related to zoning are anticipated from the implementation of the recommended plan.

7.2 Topography and Geology

The excavation and regrading of the site will alter the existing grades. However, the site will be restored to elevations similar to historical levels. The material to be excavated is fill material placed on site over the past years. As a result, there are no adverse effects related to the implementation of the recommended plan.

7.3 Soils

Temporary Construction Effects

A temporary increase in turbidity is expected during construction as a result of the earthwork. However, the work will be accomplished during low tidal periods and utilizing best management practices for erosion and sedimentation control, reducing the amount of sedimentation that could potentially enter the adjacent water bodies. Sedimentation and turbidity will be minimized, and if any does occur, it will likely settle out quickly or be dissipated by the tide. Thus, no lasting long-term adverse effects to the soils resulting from the earthwork are expected to occur.

Long-Term Effects

In general, the excavation and regrading of the site will involve the displacement of the top 1 – 3 feet of soils located on site. Material excavated from the salt marsh restoration areas will be placed in the proposed grassland area and as cover over the *Phragmites* disposal area. To complete the planting medium for the grassland, enough sand to cover a maximum of six inches over the grassland area will be imported and incorporated with on-site sand to develop a minimum 3-foot sand cover over the grassland area. As excavated materials will consist primarily of historical sand and gravel fill material that came from historic dredging of Rockaway Inlet. As the only imported soil materials will be clean sand, no adverse effects on the soils of the project site are anticipated due to implementation of the recommended plan.

7.4 Water Resources

Temporary Construction Effects

A temporary increase in turbidity is expected during the months of construction as a result of the earthwork. However, the work will be accomplished during low tidal periods and utilizing best management practices for erosion and sedimentation control, reducing the amount of sedimentation that could potentially enter the adjacent water bodies. Sedimentation and turbidity will be minimized, and if any does occur, it will likely settle out quickly or be dissipated by the tide. Thus, no lasting, long-term adverse effects to the water resources resulting from the earthwork are expected to occur.

Long-Term Effects

The excavation and regrading of material on site will significantly change the existing elevations, allowing for more land to be inundated by the daily tides. Tidal creeks will be created on site and large areas will be excavated down to low marsh elevations, both actions allowing for better overall tidal inundation. The alteration of tidal influences is necessary to provide the proper hydrology for the restoration of salt marsh habitats. The increased tidal fluctuation will allow for improved water quality, flood storage and conveyance capability, and improved fish and wildlife

habitat. Thus, positive impacts to the water resources are associated with the excavation and grade changes.

7.5 Vegetation

Implementation of the selected plan will result in a permanent conversion of relatively degraded wetland and upland vegetation to valuable salt marsh wetland and coastal/maritime grassland habitats. The extent of non-native species will be curtailed and supplanted by the incorporation of native species. Accordingly, there will be positive effects on vegetative resources as a result of implementation of the selected plan.

Furthermore, the selected plan is compatible with the Jamaica Bay Watershed Management Plan, which recommends that existing wetland and grassland areas in Jamaica Bay be restored and protected, and invasive species like *Phragmites* be controlled.

7.5.1 Wetlands

Temporary Construction Effects

Temporary impacts to wetland vegetation include the removal of vegetation during construction activities. Subsequent to completion of construction, disturbed areas will be planted and seeded as per the restoration planting plan with native salt marsh species, in effect improving the quality of vegetation on the project site.

Long-Term Effects

Implementation of the selected plan will have a long-term beneficial effect on wetlands. Within this 67-acre site, 13 acres of historically existing well-functioning low and high marsh habitat exists. The selected plan will significantly expand the small area of existing relatively high quality salt marsh that borders the open water to the greatest extent practicable by converting the adjacent *Phragmites*-dominated areas to a healthy tidal ecosystem. The selected plan will increase functioning wetland habitat to 33.5 acres, resulting in a net increase of 20.5 acres at the project site.

The selected plan will create an intertidal salt marsh system by establishing a gradual transition from open water to wetland – that is, wetland vegetation (primarily *S. alterniflora*) will occupy a gentle slope of increasing elevation. At low tide, mudflat areas will be exposed along the edges of the interface of the salt marsh and the open water area; at high tide, the mudflat and salt marsh will be flooded at varying depths, depending on its elevation. In addition, the existing fringes of tidal marsh adjacent to Gerritsen Creek and Mill Creek will continue to function as a result of overland sheet flow. Finally, the inclusion of salt pannes and open water areas interspersed within the marsh areas will increase the diversity of wetland vegetative species.

7.5.2 Uplands

Temporary Construction Effects

Temporary impacts to upland vegetation include the removal of vegetation during construction activities. Subsequent to completion of construction, disturbed areas will be planted and seeded as per the restoration planting plan with native warm season grasses, in effect improving the quality of vegetation on the project site.

Long-Term Effects

The environmental quality of uplands at the project site will be improved with the implementation of the selected plan. Of the existing 40.5 acres of *Phragmites*-dominated upland areas, 15 acres of this monoculture habitat will be converted to coastal/maritime grassland and 7.5 acres of the wooded uplands will be enhanced, greatly increasing the project site's biodiversity. The selected plan will result in only 11-percent of the project site being covered by *Phragmites*, an impressive reduction from the existing 80-percent and much closer to the historical balance that existed prior to disturbance. The *Phragmites*-dominated upland area located outside of the existing trail that runs adjacent to the golf course area along the eastern edge of the project site will be utilized for the disposal of the *Phragmites* root mat excavated from other areas of the site. This portion of the site will continue to function as a *Phragmites*-dominated area even after restoration is complete, but will be contained within the 7.5-acre area as it will be totally circumscribed by the nature trail.
Sandy materials excavated during the restoration of the salt marsh areas will be placed within the upland area in the central portion of the project site. If needed, approximately six inches of additional sandy material will be placed within this area to help achieve the soil and texture requirements necessary to create a coastal grassland community. The inland areas would then be planted with native warm season grasses like *Ammophila breviligulata*, *Panicum virgatum*, *Andropogon scoparius*, as well as flowering herbaceous species. Coastal grassland communities in Jamaica Bay currently occupy a small percentage of their historical range. Therefore, an additional environmental benefit of the project will be to increase the total amount of coastal grassland communities within Jamaica Bay.

Implementation of the selected plan includes the disturbance of all 40.5 acres of *Phragmites*-dominated uplands, including re-using the excavated rootmat within the 7.5-acre disposal area. Additionally, the conversion of 15 acres of these degraded and historically filled uplands will cause the loss of upland areas. However, these impacts will be offset by the net increase in valuable wetland habitat and an increase in environmental quality of the remaining uplands.

7.6 Fish and Wildlife

The implementation of the selected plan will include the creation of micro-niches throughout the project site to further increase habitat diversity including salt pannes, tidal channels, and open water areas at the ends of the channels.

7.6.1 Shellfish, Finfish and Benthic Resources

Temporary Construction Effects

The project may have temporary impacts to existing shellfish, finfish and benthic macroinvertebrate populations during construction. Excavation of degraded marsh areas may dislodge and eradicate both mobile and sedimentary shellfish and benthic species. In turn, this may cause a secondary impact on finfish species that feed on the shellfish and benthic species. However, the existence of shellfish species at adjacent shorelines will provide a food source for finfish during construction and allow for the recolonization of shellfish and benthic macroinvertebrates at the project site following the completion of the project. Furthermore, the ability of mobile species to relocate during construction activities, seeking food and shelter at other adjacent sites or in the deeper, undisturbed waters of Gerritsen Creek will minimize impacts to these species.

Temporary impacts also may occur during construction due to an increase in turbidity and sedimentation, which affects the ability of nearby filter feeding shellfish to feed and hinders predation efficiency of sight-feeding fish. The mobility of finfish species may allow them to avoid these impacts by moving to the deeper waters of Gerritsen Creek. However, all work will be done outside of tidal waters (i.e., during low tide). This practice, along with the use of best management practices for soil and sediment control, will minimize any potential temporary impacts.

Long-Term Effects

Implementation of the selected plan will have an overall beneficial effect on existing shellfish and macroinvertebrate species. An increase in marsh habitat and the addition of tidal channels and open water areas will increase available shellfish and benthic habitat and promote tidal inundation to larger areas of the project site, allowing for improved feeding opportunities and a reduction in predation risk. The selected plan will specifically benefit horseshoe crabs, a species now undergoing rapid and alarming population drops within the Mid-Atlantic region, as it includes the preservation of their habitat located on the sandy beaches at the southeastern end of the site.

Implementation of the selected plan will also have an overall beneficial effect on some finfish species. *Phragmites* is documented to degrade marsh function, reduce tidal exchange, and restrict the free movement of aquatic life (Weinstein and Balletto, 1999). The replacement of wetlands dominated by a monoculture of *Phragmites* with native salt marsh species will increase tidally inundated areas and the addition of tidal channels will increase the wetland/open water interface, creating new finfish habitat. In addition, the preservation of existing salt marsh areas will preserve existing finfish habitat.

7.6.2 Birds

Temporary Construction Effects

Birds at and within the vicinity of the project site may be temporarily impacted by construction activities. Heavy machinery, increased noise levels, vegetation clearing, and earth moving may cause nesting failure and/or disruptions, as well as the displacement of individuals. However, the high mobility of avian species will allow them to relocate to adjacent areas and avoid casualties.

Long-Term Effects

Even after experiencing significant losses in acreage that have reduced its ecological productivity, Gerritsen Creek and the Jamaica Bay environs are regionally and nationally important as a coastal resource, in large part because the area still contains a relatively large tract of contiguous habitat, critical to the large bird populations that utilize the area for foraging and staging. The preservation and restoration of avian habitat has become even more critical as other coastal wetlands along the eastern seaboard's major migratory route, the Atlantic Flyway, have been filled, drained, and fragmented. In addition, the project meets the goals and objectives of the North American Waterfowl Management Plan, an international agreement signed in 1986 that seeks to increase waterfowl populations through increasing and restoring wetland habitat.

Implementation of the selected plan will have a positive effect on avian populations. An increase in the biodiversity at the project site, both in the upland and wetland areas, will provide for an increase in the amount and quality of habitat and food sources for various bird species.

7.6.3 Mammals, Reptiles and Amphibians

Temporary Construction Effects

Mammals, reptiles, and amphibians currently inhabiting the project site may be temporarily displaced during construction activities. Heavy machinery, increased noise levels, vegetation clearing, and earth moving may cause the eradication of smaller, less mobile animals, as well as nesting failure and/or disruptions and displacement of other species. Mobility will allow many individuals to relocate and then return following completion of the project, but it is unavoidable that some individuals may be lost during construction. Losses are expected to be minor; therefore, no significant impacts to mammals, reptiles, and amphibians are anticipated.

Long-Term Effects

Implementation of the selected plan will benefit select mammals, reptiles, and amphibians at the project site. Increased natural biodiversity will provide for an increase in the amount and quality of upland and wetlands habitat and food sources for various mammalian species, while newly created salt marsh areas will provide additional nesting and foraging habitat for reptiles and amphibians. Reptiles such as diamondback terrapin and snapping turtles will nest in sandy uplands adjacent to tidal wetlands.

7.6.4 Rare, Threatened, Endangered and Special Concern Species

This section details the project's impacts on any documented rare, threatened, and endangered species and species of special concern within the project site and adjacent areas. Copies of agency correspondence letters are presented in Appendix E. As stated previously, all work will be done outside of tidal waters (i.e., during low tide) and best management practices will be used for this project. These methods will minimize any potential temporary or long-term impacts.

Federal Species: As stated in Section 5.6.4, no federally-listed species are documented by the USFWS at the project site and the NMFS found no endangered or threatened species in the immediate project area; therefore, no federally-listed species will be impacted due to construction of the selected plan.

As also stated in Section 5.6.4, the NMFS commented that certain anadromous or resident aquatic populations might be present in the project area.

State Species: As stated in Section 5.6.4, at the time this report was finalized, the NYSDEC had yet to provide information regarding the presence of rare, threatened, and endangered species at the project site.

7.6.5 Essential Fish Habitat

This section details the project's impacts on EFH within the project site and adjacent areas. As stated previously, all work will be done outside of tidal waters (i.e., during low tide) and best management practices will be used for this project. These methods will minimize any potential impacts to EFH. The full EFH assessment is presented in Appendix F.

The EFH Assessment indicates that the project site has been identified as EFH for 18 species of fish. However, as stated in the assessment, all work will be done outside of tidal waters (i.e.,

during low tide) and will employ best management practices, particularly for soil erosion and sediment control, minimizing any potential effect to the listed species and habitat.

Temporary Construction Effects

The project may have temporary impacts to existing EFH during construction. However, the ability of mobile EFH species to relocate during construction activities will minimize impacts to these species. Also, all work will be done outside of tidal waters (i.e., during low tide) and will employ best management practices for soil erosion and sediment control, further minimizing any temporary impacts during construction.

Long-Term Effects

The recommended plan will not cause any long-term adverse impacts to EFH or EFH species. As stated in Section 7.6.1, implementation of the selected plan will have an overall beneficial effect on existing shellfish and macroinvertebrate species. Implementation of the selected plan will also have an overall beneficial effect on some finfish species.

7.7 Socio-Economics

Temporary Construction Effects

Temporary positive effects to the economy and income will accrue from the construction of the recommended plan due to the introduction of construction workers and the resulting purchase of supplies and food.

Long-Term Effects

Implementation of the recommended plan will not have any long-term adverse effects on local population, the local economy, local income, nor on local housing.

7.8 Cultural Resources

As no previously documented prehistoric or historical archaeological resources were noted within the project area, and since there is only a slight potential for intact Native American and historical remains surviving within the project area, no negative impacts related to the development of the recommended plan are expected.
Additionally, any potential artifacts are likely to occur below the proposed excavation grade. Excavation is only proposed for areas along the perimeter of the site to relatively shallow depths. As a result, the project will not impact any potentially occurring cultural resources, as verified by the responses received from the State Historic Preservation Office and New York State Office of Parks, Recreation and Historic Preservation.

7.9 Coastal Zone Management

A Federal Consistency Assessment Form was completed for the recommended plan to determine its consistency with the policies of the NYS CMP, as well as New York City's *The New Waterfront Revitalization Program.* The completed assessment form and additional information required under Part D of the assessment are included in Appendix H. As indicated on the assessment form and supporting documentation, the recommended restoration plan is consistent with federal, state and local coastal zone management policies.

7.10 Hazardous, Toxic and Radioactive Waste

As discussed in Section 5.10, the analytical results for the soil samples obtained from the area in which the proposed salt marsh restoration will be constructed do not show the presence of contaminants or levels of contaminants of concern that would adversely affect the completed project or the public. Therefore, based on the laboratory analysis, past site use and potential future use, it is reasonable to conclude that there will not be an impact from the proposed construction. Additionally, the soils that will be excavated to create the salt marsh restoration will be used within the site to enhance the grading of the proposed grassland area and other upland areas.

7.11 Navigation

Temporary Construction Effects

The construction of the recommended plan will cause some sedimentation to be dislodged and deposited in the creek, but this sedimentation will not affect navigation.

Long-Term Effects

The recommended plan will not affect navigation on Gerritsen Creek, Mill Creek or any other nearby water bodies.

7.12 Aesthetics and Scenic Resources

Temporary Construction Effects

During construction, there will be minor adverse impacts to the aesthetic and scenic resources on site due to the presence of construction equipment, the closing of the trail, and the earthwork. However, these impacts will be temporary, and the aesthetic and scenic resources will be restored and enhanced as a result of the project implementation. All trees and shrubs that are disturbed during the construction will be replanted, and the removal of the *Phragmites* will allow for a diversity of native plant species to be installed.

Long-Term Effects

The implementation of the plan will have long-term positive effects, including enhanced unobstructed viewsheds, additional trails, improved access to the shoreline in some areas, and additional boardwalks for an increase in the number of vantage points.

7.13 Recreation

Temporary Construction Effects

During construction, there will be minor adverse impacts to recreation in the area due to the closing of the nature trail. However, construction will be phased to occur during the colder, winter months when the trail is not as heavily utilized. These impacts will be temporary.

Long-Term Effects

After the recommended plan is implemented, there will be significant positive impacts to the recreational and educational features of the site including additional walking trails and

boardwalks, enhanced wildlife habitat and viewing opportunities, and better access to the shoreline in some areas. The project will not affect any recreational activities that occur in the water, either during construction or after the project is implemented.

7.14 Transportation

Temporary Construction Effects

The proposed restoration at the project site will not generate additional vehicular trips to the site, except temporarily during the nine-month construction and planting period. There is enough capacity at the area reserved for construction access for the workers to park, so no temporary impacts to nearby street parking are expected during construction.

Access to the site will be from East 38th Street. It is anticipated that construction will be performed with a fleet of approximately eight pieces of heavy construction equipment. This equipment will require transportation to the site on trailers and will result in approximately sixteen roundtrips to mobilize the equipment to the site and demobilize them at the end of construction. Support and service vehicles would add approximately two to three roundtrips to the site each day to provide fuel and lubrication for the equipment. Additional vehicles will include those of the construction workers and supervisory personnel, which would account for approximately twelve to twenty roundtrips daily.

At this time, it is anticipated that no excavated materials will be hauled away from the site; however, construction materials, such as gravel for the paths, materials for boardwalk and walking bridges, plant material and sand will be delivered to the site. The two material deliveries that would generate the largest increase in traffic would be the delivery of gravel for the paths and the delivery of clean cover soil. Based on initial estimates of quantities, roundtrips for delivery of gravel would be approximately 90 to 100 and roundtrips for sand would be approximately 900. The number of roundtrips for sand can be reduced to zero, should an alternative means of delivering the material to the site, such as by barge, be developed.

On-site transportation of the excavated material to the upland disposal sites will occur entirely within the project site, in upland areas that have been previously filled. Improvements to these previously disturbed upland areas may be required to support the heavy machinery. The improvements may include minor widening or deposition of rock material; however, these impacts will be minor and temporary. All disturbed vegetation will be restored with native species, and all rock material will be removed.

Long-Term Effects

Subway and bus service in the area will not be affected by the proposed project. Therefore, neither local nor regional transportation will be affected by the proposed restoration.

Overall, no significant impacts related to transportation are expected as a result of the implementation of the recommended plan.

7.15 Air Quality

The project is located in an ozone non-attainment area.

Temporary Construction Effects

Heavy equipment used during construction may contribute minor amounts of carbon monoxide or other pollutants in the immediate vicinity of the project site. Off-road construction equipment used on site may produce minor amounts of National Ambient Air Quality Standards (NAAQS) criteria pollutants in the immediate vicinity of the project site. However, construction activities would have no significant or long-term impacts on air quality.

Long-Term Effects

A Record of Non-Applicability (RONA), presented in Appendix K, will be submitted to the Chief of Planning for signature, upon completion of the Plans and Specifications Phase of this project. Based on the information deduced from the current 30 percent design, it appears that emission calculations put the project under the conformity threshold value of 25 tons per year for nitrous oxide and ozone precursors.

7.16 Noise

Temporary Construction Effects

There will be a minor, temporary increase in noise levels in the immediate project area during construction due to the increase in worker vehicles and traffic, and the operation of construction equipment. However, these impacts are expected to be minimal and short-term, and limited to the daytime hours during the period of construction.

During construction the temporary short-term impacts to ambient noise levels from construction equipment will occur during normal working hours. It is anticipated that most of the construction activities associated with the proposed excavation and grading work will not generate continually high noise levels, occasional single event disturbances may occur. Construction equipment noise is controlled by the Environmental Protection Agency's Noise Control Program (Part 204 of Title 40, CFR).

Approximately eight pieces of heavy equipment will be utilized to excavate and grade the site. Noise levels from the construction equipment anticipated to be utilized at the site can range from 85 dB to 88 dB at 50 feet from the equipment. As the distance from the operating equipment increases, the decibel level drops; however, it can be assumed that the decibel levels will still be above ambient background levels near the limits of work. The major portions of the excavation and grading work will be performed at distances in excess of 1,000 feet from the nearest residences. However, the construction staging area may fall within 800 feet of the nearest residences along the north side of East 38th Street.

Noise would also be generated during construction activities by the increased traffic associated with the delivery of materials and heavy equipment. Noise associated with gravel and clean fill delivery will also occur during construction and would be short term in nature and limited to normal working hours.

Long-Term Construction Effects

Overall, there are no significant impacts to noise related to the implementation of the recommended plan.

7.17 Cumulative Impacts

The Gerritsen Creek project has been assessed within the context of the region to evaluate potential cumulative impacts. Included in this assessment are other planning and/or construction projects that are currently being undertaken in the vicinity of the Gerritsen Creek Project having or potentially impacting the natural resources of Jamaica Bay area. A brief summary of these projects are listed below.

U.S. Army Corps of Engineer Projects

Fresh Creek and Spring Creek: Salt marsh restoration projects are planned at Fresh Creek and Spring Creek, north of the Belt Parkway. These projects are being progressed jointly by the Corps and NYCDPR. The Spring Creek salt marsh restoration project forecasts design for 2003-2004 and construction in 2004-2005. These projects are funded through the Continuing Authorities Program (CAP).

Jamaica Bay Ecosystem Research and Restoration Team Sites: Ecosystem restoration projects are being planned for the eight Jamaica Bay Ecosystem Research and Restoration Team sites which include: Dead Horse Bay, Spring Creek, Paerdaget Basin, Fresh Creek, Hawtree Point, Bayswater Park, Dubos Point and Brant Point.

Other Salt Marsh Restorations: Salt marsh restorations are in the conceptual planning stage for several other salt marsh islands in Jamaica Bay over the next several years. These include Yellow Bar, Elders Point, Black Wall, Black Bank, and Hendrix Creek. The Corps has CAP funds plus matching funds from New York City and the NYSDEC for these projects.

Projects within the Jamaica Bay Wildlife Refuge

Big Egg Marsh Restoration Demonstration: The National Park Service is proposing to implement a demonstration marsh restoration project encompassing approximately 2 acres of Big Egg Marsh within the Jamaica Bay Wildlife Refuge. The purpose of the demonstration project is to evaluate the use of the thin-layer method of placing dredged sediment onto a deteriorating tidal marsh as a means of reestablishing the vegetative cover of the marsh.

Bike Path Environmental Assessment: An environmental assessment was prepared in 2000 for the construction of a NYSDEC-sponsored multi-use pathway along the west side of Cross Bay Boulevard, partially within the boundary of Gateway National Recreation Area.

Jamaica Bay Visitor Contact Station and Refuge Support Facility Environmental Assessment: An environmental assessment was prepared in January of 2003 for the construction and expansion of the existing Jamaica Bay Wildlife Refuge Visitor Contact Station and the Refuge Support Office.

Paerdegat Basin Water Quality Facility Plan Final Environmental Impact Statement: A Final Environmental Impact Statement was prepared in March 1994 for proposed activities at Paerdegat Basin. Activities include rebuilding a sewage treatment plant, installing a 30 million gallon retention tank, dredging the mouth of the tributary for barge traffic, dredging the upper end of the tributary to remove odor-causing sludge, restoring approximately 82 acres of salt marsh and tidal habitat, and restoring 95 acres of adjacent upland vegetation. The project is currently in design and construction is planned for 2005-2006.

Rockaway Boulevard Development: The Port Authority is developing its property located along Rockaway Boulevard.

New York City Projects

New York City projects at various states of planning or construction include the following projects:

- Closing two landfills (Penn and Fountain Landfills) at the north edge of Jamaica Bay on both sides of Hendrix Creek.
- NYCDPR is finishing a salt marsh restoration at Four Sparrow Marsh Park.
- New York City Department of Transportation will be rebuilding or replacing seven bridges located along the Belt Parkway on the north side of Jamaica Bay between Gerritsen Inlet and Spring Creek over the next several years.
- Two acres of salt marsh restoration at Idlewild Park are currently under construction.

Miscellaneous Other Projects

Other projects at various stages of planning or construction include the following projects:

- Restoration of Whyte Island, between Gerritsen Creek and Mill Creek, as mitigation for construction of the Gateway Estates Shopping Mall.
- Restoration of Whyte Island, between Gerritsen Creek and Mill Creek, as mitigation for construction of the Gateway Estates Shopping Mall.
- High speed ferry dock and dredging in Bergen Basin for the JFK Airport.
- Two small projects to restore salt marsh and adjacent upland vegetation at Bergen Beach (south of Paerdegat Basin) and at Hendrix Creek. NYSDEC is using State Bond Act funds for this restoration.
- Marsh restoration at the Penn and Fountain Avenue landfill perimeters.
- Gateway Marina in Dead Horse Bay recently renovated its pilings, floating docks, and parking lots.
- Docks at Fort Tilden are being rebuilt for a ferry dock.
- Dredging at the mouth of Sheepshead Bay might be needed for party boats in the next few years.
- A dock is likely to be constructed at Motts Basin for a new electric plant.

Summary and Conclusions

The restoration plan for the Gerritsen Creek area has been considered in the context of other salt marsh restoration projects in the Jamaica Bay area. Overall, the cumulative effects of all of these restoration projects will be to enhance existing opportunities for water quality, recreation, and fish and wildlife habitat.

The other projects (other than restoration) scheduled to occur within the Jamaica Bay area occur outside of the Gerritsen Creek channel. As a result, the recommended plan is not anticipated to add cumulatively to projected effects of these projects on the natural resources of the area. Physical activities associated with these projects within the Jamaica Bay area do not occur in the proximity of Gerritsen Creek.

The recommended plan will not conflict with the planned bike path, but will actually create some benefits. The bike path is scheduled to go past the existing Nature Center. Therefore, any

improvements associated with the Gerritsen Creek project area will benefit the bike path user by increasing recreation opportunities and aesthetics.

As discussed in the previous sections, there are no long-term adverse effects predicted to occur to the aquatic or upland ecosystem as a result of the implementation of the recommended plan. In fact, cumulative adverse effects in Jamaica Bay caused by activities associated with the projects listed above could be offset by the positive effects of the Gerritsen Creek restoration project.

PART 8 – REGULATORY APPROVALS

To implement the proposed restoration plan, a number of regulatory approvals must first be requested by the USACE and NYCDPR, and approved of by the jurisdictional agencies. The permit approvals that will be applied for include:

1. Joint Permit Application to be submitted to the NYSDEC and USACE for the following:
   - Tidal Wetlands Permit;
   - Coastal Erosion Control; and
   - Section 401 Water Quality Certification.
2. Coastal Zone Consistency Determination to be submitted to the New York State Department of State (NYSDOS).
3. Essential Fish Habitat assessment to be submitted to the NMFS.

Copies of the permit applications are presented in Appendix I, a copy of the Coastal Consistency Assessment is presented in Appendix H, and a copy of the Essential Fish Habitat assessment is located in Appendix F. In accordance with Section 404 requirements, a Section 404(b)(1) analysis for the restoration of the tidal marsh at Gerritsen Creek was also completed and is presented in Appendix J. In preliminary discussions with the regulatory agencies, representatives have indicated that the project appears to be in compliance with all applicable regulations.

PART 9 – PROJECT IMPLEMENTATION

Upon completion of the Final Design Development of the Selected Plan, a Project Cooperation Agreement (PCA), which outlines the project costs, tasks, and expectations for the completion of the project, will be completed and signed by the USACE and the non-federal sponsor, NYCDPR. This agreement outlines the terms and conditions of the relationship between the federal government and the non-federal sponsor for construction, operation, and maintenance of the project and will include costs for the plans and specifications phase, as well as for construction. In accordance with the NEPA-EA process, the New York District of the USACE will allow for a period of public review and comment on the project, and respond to public comments (see the following section regarding the public involvement). Additionally, the New York District has attended a pre-application meeting with the NYSDEC, and has compiled and will be submitting all of the necessary permits required for the implementation of the project (see Appendix I). Following approval of all permits and funding, the project will proceed to the implementation phase, and finally to construction, monitoring and maintenance.

PART 10 – PUBLIC AND AGENCY INVOLVEMENT

Public and agency involvement and coordination in USACE projects are an integral part of the planning process and are required in accordance with NEPA, USACE and New York State Environmental Quality Review Act regulations. Involving the public and agencies at an early phase in the planning process can greatly improve the overall chances of project success by eliciting and addressing comments and input throughout the process, and revising the design at an early stage to reflect these comments and concerns.

The USACE has solicited input from NYCDPR, NYSDEC, USFWS and NMFS since the inception of the planning for this restoration. Venues for agency input included electronic mails, telephone conversations, letters and interagency meetings, including the following:

- Inter-Agency Briefing, Friday, November 15, 2002: Attended by NYCDPR, USACE, NYSDEC, local council members, congressional representatives, local community boards representatives, and the design consultants. NYCDPR and USACE provided a briefing on the project alternatives and the recommended restoration plan.
- Community Board 18 Meeting, Wednesday, November 20, 2002: USACE and NYCDPR representatives provided to the Community Board members and the attending public an introduction to the restoration project, the project alternatives, and the recommended restoration plan, as well as information on the general public meetings to be held in November 2002.
- Pre-Application Meeting, Tuesday, December 10, 2002: Attended by the NYSDEC and USACE and the design consultants, to obtain input on the recommended restoration plan and review regulatory approvals necessary to implement the project.
- Public Information Meeting and Site Walk, Thursday, 1:00 pm – 4:00 pm, December 12, 2002: Included a tour of the site led by USACE and NYCDPR representatives, and presentations by the USACE and NYCDPR on the project objectives, alternatives analysis, and recommended restoration plan.
- Public Information Meeting, Thursday, 7:00 pm – 10:00 pm, December 12, 2002: Included presentations by the USACE and NYCDPR on the project objectives, alternatives analysis, and recommended restoration plan.

The Integrated ERR/EA will be made available to all interested agencies and the general public for review and comment upon its completion.

PART 11 – MONITORING AND MANAGEMENT

All monitoring and management conducted for the restored Gerritsen Creek will be performed in accordance with federal and state regulations and standards. The goal of the monitoring and management program will be to accurately determine the success of the restoration efforts relative to anticipated performance standards, quickly identify any problems requiring remedial action, and implementation of those remedial actions on a timely basis.

Post-construction monitoring and management will be performed over a period of five years during the first, third and fifth years, beginning with an initial monitoring event immediately following completion of the restoration of the site. The success of the restoration efforts will be measured by performance standards developed in the *New York State Salt Marsh Restoration and Monitoring Guidelines* (NYSDEC, 2000) and as defined in a monitoring work plan.

11.1 Responsible Parties

The responsible party for the Gerritsen Creek monitoring will be NYCDPR. Other responsible parties that may be involved include the USACE and the NYSDEC.

The USACE is the lead designer for the project and as such will be responsible for including monitoring specifications in the design and site plan, including specific locations of transects, quadrats, permanent fixed-point photo stations, and other features.

The regulatory agency responsible for approving the restoration designs, monitoring protocols, and any required permitting for restoration activities is the NYSDEC.

The NYSDEC is responsible for the regulatory permit approval of the environmental impacts associated with the implementation of the restoration design, as well as approval of the monitoring protocols required to demonstrate project compliance.

11.2 Purpose

The purpose of the monitoring is to assess the progress towards, and the success or failure of, the restoration of the salt marsh habitat and coastal grassland habitat at Gerritsen Creek and the achievement of acceptable standards of salt marsh and coastal grassland character and function. At a minimum, this will include an assessment of the vegetation development, soil profiles, colonization by benthic invertebrates, and habitat usage by macrofauna, as described below.

11.3 Monitoring Protocol Design

A work plan for all monitoring activities shall be written by NYCDPR, with input from USACE, and shall be approved by the NYSDEC. The recommendations outlined in Sections 11.3 through 11.6 below were based on the *New York State Salt Marsh Restoration and Monitoring Guidelines* (NYSDEC, 2000). Where necessary and appropriate, the plan shall include site-specific modifications to the recommended monitoring protocol. Monitoring parameters and activities shall be clearly articulated and documented in the work plan. The monitoring protocol shall include the following study methods:

- Control Transects – restored/enhanced and reference areas;
- Quadrats – at least three per control transect;
- Permanent Fixed-point Photo Stations – located at both ends of each of the transects;
- Video-monitoring (optional) – film panoramic view of the site, close-ups of flora and/or fauna, views of different vegetation zones, and/or walk along transects end-to-end; and
- Aerial Infrared Photography (optional) – use to assess large-scale vegetation cover.

Monitoring at the project site shall be conducted in the restored salt marsh and coastal grassland areas and at a minimum of three reference areas. At least one of the reference areas shall be located within the 13 acres of existing salt marsh, while another shall be located within an existing coastal grassland area. The third reference site may be a recent tidal wetland restoration within Jamaica Bay. A control transect will be set at each monitoring area, along which three quadrats shall be placed. The permanent fixed-point photo stations shall be located at the ends of the control transects. In addition, an overview photo station should be selected that includes a panoramic view of the entire project site. The location code, view direction, time, date, and site conditions shall be documented for all photographs.

The work plan shall detail the number and location of each of the control transects and quadrats. All transects, quadrats, and photo stations shall be assigned location codes that shall be marked on a site map to be included in the work plan.

The purpose of monitoring reference areas is to discern background environmental effects from the effects attributable to the project. For example, vegetation parameters within the restored salt marsh areas must be compared with the same parameters at the marsh reference areas to determine whether an observed loss of vegetation is a restoration failure or due to a natural event, such as a winter storm that has similarly affected all marsh communities in the area.

11.4 Pre-Restoration Monitoring Activities

For the reference areas (existing marsh and coastal grassland areas that will not be disturbed), all parameters described below under Section 11.5 Post Construction Monitoring shall be monitored at least once prior to construction, preferably during August/September prior to commencement of construction. The work plan may call for May and December parameters to be included for these areas in pre-construction monitoring activities during the year prior to construction.

For the restored/enhanced areas (areas that will be planted post-construction), color photographs shall be taken at the permanent fixed-point photo station locations prior to any construction activities. Photographs shall also be taken at the fixed point photo station locations of the selected reference areas, as well as the project site overview location.

11.5 Post-Construction Assessment (Immediately following Construction)

Immediately following construction and prior to planting, the project site shall be walked by NYCDPR, the USACE, and the NYSDEC to assess compliance with submitted work plans. Elevations shall be double checked prior to planting. Color photographs shall be taken at all of the permanent fixed-point photo station locations. Based on the assessment immediately following construction, NYCDPR shall determine whether any additional work is required to achieve work plan compliance.

11.6 Post-Construction Monitoring (Long-Term)

The following parameters should be monitored over a period of five years during the first, third and fifth years following completion of restoration activities at all control transects specified in the work plan. All monitoring activities shall occur at appropriate tides. The August/September monitoring shall include documentation with color photographs at all fixed-point photo stations, as well as the project site overview location.

Subject to revisions and final agreements, it is anticipated that the following parameters will be monitored once during the last week of August or the first three weeks in September:

Tidal Wetland Monitoring:

1. Wetland Vegetation – monitor at each quadrat
    - Plant species occurring;
    - Stem density;
    - Plant height;

- Signs of disease, predation or other disturbance;
- Vegetation zones; and,
- Number of flowering stems.

2. Soil Properties – composite of at least two samples for each quadrat
   - Soil organic matter and
   - Soil salinity.

3. Benthic Invertebrates – counted for each quadrat
   - Ribbed mussels (also measure two to six for length);
   - Fiddler crab burrows (also note live fiddler crabs); and
   - Other benthic invertebrates observed.

The following parameters shall be monitored during the appropriate months according to industry standards and consistent with protocols for existing baseline data in the Marine Park area:

4. Birds
   - Breeding bird census;
   - Wading bird strike study;
   - Shorebird survey; and
   - Winter waterfowl count.

Note: Observation locations for birds shall be selected to minimize disturbance to the species (i.e., an obscured location on the landward side of the project site).

5. Juvenile Fish Sampling – Sampling with nets and minnow traps shall be conducted in the summer months to determine general diversity and abundance of fish species using the restoration area.

6. Other Macrofauna – record numbers of species and individuals (or reasonable evidence of presence) of macrofauna at project site such as small mammals, horseshoe crabs, amphibians, reptiles, etc.

Grassland Monitoring:

7. Vegetation – Line-intercept sampling along permanent transects shall be conducted sometime in August or September, with the following attributes recorded:
   - Horizontal distribution; and
   - Vertical structure.

8. Avian – The following parameters shall be monitored during the appropriate months according to industry standards and consistent with protocols for existing baseline data in the Marine Park area:
   - Breeding bird survey; and
   - Nocturnal bird survey.

9. Other Macrofauna – A survey will be made during the appropriate Spring months for nesting of turtles within the grassland area.

11.7 Monitoring Reporting Requirements

Monitoring reports will be written and submitted to NYSDEC by December 1 of each of the three monitoring years and will begin after the first post-construction growing season. Included in each report shall be the monitoring data, photographs, and a brief summary of the collected data. At the end of the five-year monitoring commitment, a summary report of the entire monitoring efforts and results shall be compiled.

PART 12 – SUMMARY AND CONCLUSIONS

The USACE has completed this Integrated ERR/EA in accordance with the requirements of the NEPA, to assess the need for modifying the existing degraded habitat, evaluate the effects of the restoration activities, and determine a solution that maximizes the environmental benefits while minimizing the economic costs for the Gerritsen Creek Ecosystem Restoration Project.

The purpose of the project is to ameliorate the adverse impacts associated with the past filling activities on the project site, with the overall purpose being to improve the environmental quality of the area. This area was altered in the past due to dredging and filling activities and, as a result, is less productive than the pre-existing ecosystem habitat.

The Gerritsen Creek ecosystem restoration is being conducted under Section 1135 of the Water Resources Development Act of 1986, as amended. Under Section 1135, the USACE is authorized to review the need for modifications of existing projects for the purpose of providing measures to improve environmental quality and is authorized to address degradation of the environment caused by a past USACE project.

The Gerritsen Creek project site targeted for ecosystem restoration is an approximately 67-acre site that lies within the Jamaica Bay watershed in Marine Park, Brooklyn, New York. Field observations of the site in its existing state indicate that the ecology of the area has been degraded, primarily due to past activities that included dredging and filling activities. These activities have resulted in the loss of tidal wetlands and open water areas, and created a dominance of *Phragmites*.

Based on the preliminary investigations, it is evident that a small fringe of healthy tidal wetlands exists on site, and larger areas of healthy tidal wetlands exist nearby within Marine Park and Jamaica Bay. Therefore, it is likely that the disturbed areas within the project site that received fill in the past can be restored to healthy tidal wetland ecosystems. In addition, upland areas that have been the site of filling can be restored to coastal grassland areas.

The proposed project includes the restoration of approximately 35.5 acres of habitat, including approximately 20.5 acres of intertidal salt marsh and approximately 15 acres of coastal/maritime grassland. The proposed restoration will be accomplished through a combination of excavation, recontouring, and native species' plantings.

The proposed project is the result of an analysis of an initial three alternatives for restoring the disturbed areas on site to healthy tidal marshes and coastal grassland. A fourth alternative was added after it was discovered during site investigations, that a major portion of the area to be restored in these alternatives contained trash that would have to be removed and would adversely impact the cost of implementing these alternatives. The fourth alternative extended the project

along the Mill Creek shoreline and incorporated new design features including additional tidal channels and open water areas and an increase in the coastal grassland areas.

The environmental effects of the recommended plan on the physical, ecological, cultural, aesthetic, socioeconomic, and recreational conditions of the existing site were evaluated and a determination has been made that no long-term, adverse impacts are anticipated as a result of implementing the recommended plan and the implementation will have no negative impacts on the quality of the environment.

CONCLUSIONS: Alternative 4, a restoration plan that includes the restoration of approximately 35.5 acres of habitat, including approximately 20.5 acres of inter-tidal salt marsh and approximately 15 acres of coastal/maritime grassland, was selected as the most cost efficient habitat restoration for the Gerritsen Creek site. The avoidance of excavating any areas that may have received trash in the past minimizes the associated costs, while still allowing for maximum project benefits.

RECOMMENDATIONS: It is recommended that the New York District and NYCDPR secure the necessary funds to implement the selected plan. The restoration plan is consistent with current administration policy and, if implemented, will provide measurable environmental benefits.

Date: _____

_____
John B. O'Dowd
Colonel, Corps of Engineers
District Engineer

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PART 14 – ACRONYMS

A listing of the acronyms used in this report is provided below.

Acronym	Title
CE	Cost Effectiveness
CEA	Critical Environmental Area
CY	Cubic yards
DR	Diurnal Range
EA	Environmental Assessment
EFH	Essential Fish Habitat
EPW	Evaluation of Planned Wetlands
ER	Engineering Regulation
ERR	Ecosystem Restoration Report
FCI	Functional Capacity Index
FCU	Functional Capacity Unit
FT	Fish (tidal)
FT BGS	Feet below ground surface
HEP	Harbor Estuary Program
HTRW	Hazardous/Toxic/Radiological Waste
Hz	Hertz
ICA	Incremental Cost Analysis
IDC	Interest During Construction
JABERRT	Jamaica Bay Ecosystem Research and Restoration Team
KG	Kilograms
MHHW	Mean Higher High Water
MHW	Mean High Water
MHWS	Mean High Water Spring
MLLW	Mean Lower Low Water
MLW	Mean Low Water
MLWS	Mean Low Water Spring
MCACES	Micro-Computer Aided Cost Estimating System
UG	Micrograms
MG	Milligrams
Mph	Miles Per Hour
MR	Mean Range
MTL	Mean Tide Level
NA	Non-applicable
NAD	North American Datum
NAVD88	North American Vertical Datum 1988
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NYCDCP	New York City Department of City Planning
NYCDEP	New York City Department of Environmental Protection
NYSDEC	New York State Department of Environmental Conservation
NYCDPR	The City of New York Department of Parks and Recreation

Acronym	Title
O&M	Operation and Maintenance
PCA	Project Cooperation Agreement
PCB	Pesticides/Polychlorinated Biphenyls
RCRA	Resource Conservation and Recovery Act
SB	Shoreline Bank Erosion Control
SHPO	State Historic Preservation Office
SNWA	Special Natural Waterfront Area
SR	Spring Range
SS	Sediment Stabilization
TAGM	Technical and Guidance Memorandum
UH	Uniqueness/Heritage
USACE	United States Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
WAA	Wetland Assessment Area
WL	Wildlife
WQ	Water Quality